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INDEX.

PAGE

ABNORMALITIES in postcava of cat 185
Absaroka Range, Volcanoes of . 156
Actinaria, Synopsis of 747
African masks and secret societies 973
Agriculture, Practical 906
Aleurodidæ 825
Algæ, Alternation of generations . 678
—— and fungus in lichens . . . 245
Allen, J. A. Mammals of New York 316
—— North American jumping mice 199
Alternation of generations . . . 165
—— in algæ 678
Amblystoma 552
Amia, Intestine of 717
Amœba, Reproduction of . . . 441
—— Sporulation in 332
Andrews, E. A. Merogeny . . . 982
—— Davenport's Zoölogy . . . 981
—— Physics of cell life 54
—— Protoplasm of the salmon egg 322
—— Protoplasmic streamings . . 434
—— Sporulation in Amœba . . 332
—— Structure in the mammalian egg 320
—— The tree-frog 322
Animal and plant colors 759
Annelids, Alternate generations in 165
—— Sense organs of . . . 71, 328
Anthropological Notes 53, 145, 311, 433, 977
Ants of Texas 563
Anura, Breeding and development of 687
Appointments 83, 244, 530, 613, 683, 823
Aquaria, Fresh-water 203
Arachnid (Kœnenia) in Texas . . 837
Arctic deep-sea fauna 442
—— marine animals 443
Arizona, Faunal zones in . . . 284
Arrowheads 431
Ascidians of Bremer Expedition . 765
—— Nervous and glandular tissue in 766
Atta 851
Attaphila 856

PAGE

Australian Fauna 25
—— Fishes 438
Autolytus, Life history of . . . 165
Axolotl, Remarkable 551

BAKER, F. C. A new museum tablet 275
Banks, N. Synopsis of scorpions, solpugids, and Pedipalpi . . . 421
Batrachus, Lateral line of . . . 235
Bdellostoma, Caudal heart . . . 666
Beaufort, Marine biology at . . . 339
Beecher, C. E. Zittell's text-book of paleontology 680
Bees of cactus 487
Bigelow, R. P. Study of heredity among the deaf 146
Biology, Advance of, in 1897 . . 489
Birds, Arctic 417
—— of California 440
—— Dental ridges of 677
—— and Dinosaurs 777
—— of France 602
Blattid, New 856
Blind vertebrates 524
Bones, Arrangement of collections 9
Botanical Notes, 75, 241, 449, 608, 680, 767, 828, 907, 989
Botany, Briefer courses in . . . 905
—— Experimental 605
—— Text-book of 828

CALIFORNIA, Birds of 440
Canada, Phenological observations in 445
Canals, Intracellular, in ganglion cells 762
Cancroid crabs of North America 131
Cannon, W. A. Gall of the Monterey pine 801
Capillaries and sinusoids 527
Caprifoliaceæ and insects . . . 37
Castle, W. E. Studies on Hirudinea 600
Cat, duodenal glands 233
—— Postcaval abnormalities in . 185
Catometopous crabs 583
Cell, Wilson's Work on 761
—— Division 236

PAGE

Cell, in Sporangia and Asci . . . 448
—— Life, Physics of 54
Cephalopods, Fossil, in the Timan 830
—— Russian carboniferous . . . 831
Cestode nomenclature 533
Ceylon, Flora of 447
Chirostoma 523
Circulation in Anodonta 154
Clements, F. E. Minnesota plant life 238
Cockerell, T. D. A. The Aleurodidæ 825
—— The cactus bees 487
—— Lower and middle Sonorian zones 284
Collins, F. S. Alternation of generations in algæ 678
Colors of animals and plants . . 759
Crawley, H. A flagellate heliozoön 255
Crayfish, Psychophysiology of . . 821
Cretaceous plants 608
Cutting ants, Myrmicophila with . 851
Cycads, Fossil 609, 610
Cyclometopa of North America . 131

Daphnia, Variation in 879
Davenport, C. B. Advance of biology in 1897 489
—— Biology of crystals 978
—— Variation in Pecten 863
—— Variation of Statoblasts of Pectinatella 989
Deaf, Marriages of 146
Deaths . 84, 224, 532, 613, 684, 838
Didelphis 575
Dinocerata, Limbs of 89
Dinosaurs and birds 777
Distomum (n. sp.) in American frogs 811
Distribution of animals in Australia 25
Dog, Diseases of 598
Duncker, G. Variation in Palæmonetes 621
Duodenal glands in cat 233

Ear bones 526
Easter Island 430
Eastman, C. R. Karpinsky's genus Helicoprion 579
Eaton, E. H. Zoölogy of the Horn Expedition 25
Echinoderms, New text-book on . 675
Eciton 563
Edestidæ 579
Editorial comment 819
Egg of mammals 320
Eigenmann, C. H., and Shafer, G. D. Cones in the retina of fishes 109
Elbe, Plankton of 761

Embryology, Mammalian . . . 913
Enteman, M. M. Variations in Daphnia 879
Enteropneusta 123
Excretion in Mollusca 151
Experimental petrography . . . 160
Eyes of Crustacea 72
—— of fishes 109
—— of Polyphemidæ 72

Fermentation 679
Fishes of Australia 438
—— Compensatory movements in 669
—— Deep-sea 663, 910
—— Fossil 612, 876
—— of Hawaii 666
—— of Mexico 667
—— of North America 764
—— Notes on 668, 897
—— Psychology of 275
—— of Puerto Rico 150
—— tide-pool 233
—— of Woods Holl 523
Flagellata, Colonial 331
Formaldehyde 763
France, Birds of 602
—— Fauna of 902
Frogs, Distomum in 811
Fungus and alga in lichens . . . 245

Galls on pine 801
Ganglion cells, Intracellular canals in 762
Gardening, Dictionary of 905
Gatschet, A. S. Payne's New World 231
Genital organs of Zaitha 119
Geological phenomena, Interpretation of 495
Grafted Tissue, Regeneration in . 155
Grafting Hydra 237
—— Medusæ 155
—— pupæ of moths 236
Grapsoid crabs 583
Growth and food supply in starfish 17
Growth, Effects of heat on . . . 949

Hagfish, Caudal heart of . . . 666
—— Eggs of 437
Hargitt, C. W. Natural history of Pennaria 387
Hawaiian fishes 666
Heart, Caudal, of hagfish . . . 666
Heat, Accelerating effect of, on growth 949
Helicoprion 579
Heliotropism of Cypridopsis . . 603
Heliozoön, Flagellate 255
Hemiptera, Genital organs of . . 119
Henshaw, S. A recent book on insects 326

PAGE

Henshaw, S. New Jersey insects . 673
Heredity among deaf 146
Heterocotylea, Synopsis of . . . 645
Heteropods, Otocyst of 526
Hexapod leg, Segments of . . . 267
Hilton, W. A. Intestine of Amia calva 717
Hirudinea 600
Hoffman, R. Seton-Thompson's trail of the sandhill stag . . . 319
—— Lanier's "Bob" 320
—— Lang's our native birds . . 321
—— Acloque's "Oiseaux" . . . 602
Hopi Indians 53
Horn Expedition, Zoölogy of . . 25
Horticulture, Cyclopedia of, 335, 767
Hrdlicka, A. Arrangement of collections of bones 9
Hyatt, A. V. Woodroffe's Management and diseases of the dog 598
Hydra grafts 237
Hydroid, New 237

INDIAN knives 431
Infusoria, Breeding of 328
—— Reaction of, to chemicals . . 259
—— of Switzerland 329
Innate ideas, Problem of 822
Insects and Caprifoliaceæ . . . 37
—— of New Jersey 673
—— Ocelli of 641
Instinct or reason 817
Intestine, Histology of 527
Intestine of Amia 717
Iris, fruiting of 361
Irish, H. C. James's practical agriculture 906
—— Phenological observations in Canada 445
Isopoda, Synopsis of . . . 207, 295

JACKSON, R. T. Newberry's later extinct floras 79
Jagger, T. A., Jr. Experimental geology 772
—— Geology of Yellowstone Park 770
—— Maryland Geological Survey 773
—— Maryland Weather Service 772
—— Tertiary volcanoes of the Absaroka Range 156
Jar for laboratories 971
Jennings, H. S. Reaction of Infusoria to chemicals 259
Johnston, J. B. A sealing stone jar for zoölogical laboratories . 971
Jordan, D. S. Blatchley's gleanings from nature 149
—— Caudal heart of hagfish . . 666
—— Clapp on the lateral line of toadfish 234

PAGE

Jordan, D. S. Eggs of hagfish . . 437
—— Garman's deep-sea fishes . . 663
—— Greeley's tide-pool fishes . . 233
—— Labroid fishes of Hawaii . . 666
—— Lungless salamanders . . . 437
—— Notes on fishes, 68, 69, 70, 897
—— Vertebrates of the Philippines 436
—— Waite's fishes of the Thetis expedition 438
—— Whitefish of Lake Chapala . 523
—— Woodward on Scapanorhynchus and Mitsukurina . . 234
—— Evermann and Marsh on fishes from Puerto Rico . 150
Jordan, D. S., and Snyder. Fishes of Mexico 667

KOCHI, C. Origin of middle ocellus of insects 641
Kœnenia 837
Kofoid, C. A. Abyssal Rhizopoda 330
—— Effect of staleness of sex-cells on development 823
—— Growth in the Rhizopod shell 329
—— Plankton of the Elbe . . . 761
—— Protozoan studies 824
—— Swiss Infusoria 329

LAKE URMI 315
Lamprey, nesting habits of . . . 617
Lateral line of toadfish 235
Leech, A new 524
Leeches, Studies on 600
Lepidosiren, Development of . . 670
Leucosoid crabs 503
Lichens, Fungus and alga in . . 245
Lillie, F. R. Regeneration and regulation in Planarians . . . 173
Linnæus, Fishes of 69
Lithurgus 487
Lovell, J. H. Insects and Caprifoliaceæ 37
Loxosoma, Double 891
Lycodes 439

MAIOID Crabs 503
Mammalian egg 320
Mammalian embryology 913
Mammalia, Origin of 943
Mammals of New York 316
—— of Prince Edward Island . . 483
Man, Antiquity of 145
—— Races of 521
—— Variations in crania . . . 737
Mark, E. L. Godelewski's multiplication of nuclei 671
Maryland Geological Survey . . 773
—— Weather Service 772
Masks, African 973

PAGE

McClure, Postcaval abnormalities in cat 185
McNiel, J. Variation in venation of Trimerotropis 471
Mead, A. D. Growth and food supply in starfish 17
Meek, S. E. Jordan and Evermann's fishes 764
Melophagus ovinus 327
Mensch, P. C. Life history of Autolytus and alternation of generation in annelids 165
Metcalf, M. M. Willey on Enteropneusta 123
Mexico, Fishes of 667
Mice, North American jumping . 199
Microbdella 524
Micro-organisms and fermentation 679
Microthelyphonida 837
Minnesota plant life 238
Minot, C. S. Study of mammalian embryology 913
Mollusca, Circulation in 154
—— Excretion in 151
Monascidians of the Bremer Expedition 765
Monterey pine, Gall of 801
Montgomery, T. H. Genital organs of Zaitha 119
Murbach, L. Fresh-water Aquaria 203
Muscle, Nuclei of 671
Musical bow 429
Myrmicophaga 575
Myrmicophile, New 851
Myxine, Eggs of 437

Necturus, Position of sacrum in 635
Needham, J. G. Fruiting of Iris . 361
Nematode in panther 72
Nepheline-syenites 453
Nereis, Sense organs of 328
Neurone theory 61, 64, 457
New England, Local floras of . . 240
New Jersey, Insects of 674
New Mexico, Faunal zones in . . 284
News . . 83, 244, 529, 613, 683, 832
New York, Mammals of 316
Niagara, Age of 145
Nickerson, W. S. Distomum in American frogs 811
—— Double Loxosomæ 891
Norman, W. W. San Marcos salamander, Typhlomolge 179
North Dakota, Axolotl from . . 551
Norton, J. B. S. Classification of odors 241
—— Nuclear phenomena in Ustilagineæ 448
Nuclei, Multiplication of, in muscle 671
—— of Ustilagineæ 448

PAGE

Occipital condyles 943
Ocelli of hexapods 641
Odors, Classification of 241
Oöcapt 533
Opilionidæ, Distribution of . . . 597
Ortmann, A. E. Arctic deep-sea fauna 442
—— Arctic marine animals . . . 443
—— Distribution of Opilionidæ . 597
—— Zoögeography of the Pacific . 594
Osborn, H. F. Angulation of limbs of quadrupeds in adaptation to weight 89
—— Evidence for a common dinosaur-avian stem in the Permian 777
—— Glacial pot hole near Catskill, N. Y. 33
—— Origin of the mammalia . . 943
—— Vertebræ of reptiles . . . 1
Osborn, H. L. Remarkable axolotl from North Dakota 551
Ossicula auditus 526
Otocyst of heteropods 526
Ovogenesis in tunicates 441

Pacific, Zoögeography of . . . 594
Paleontology, Text-book of . . . 681
Palpigradi 837
Parker, G. H. Amitotic followed by mitotic division 236
—— Ampullæ of Tunicata . . . 71
—— A new hydroid 237
—— Animal and plant colors . . 759
—— Artificial production of rhythmic muscle contractions . 150
—— Barker's nervous system . . 61
—— Capillaries and sinusoids . . 527
—— Compensatory movements in fishes 669
—— Development of Lepidosiren 670
—— Ear bones 526
—— Elementary physiology . . 763
—— Formaldehyde 763
—— Grafting and regeneration in Hydromedusæ 155
—— Heart of Anodonta 154
—— Hydra grafts 237
—— Intracellular canals in ganglion cells 762
—— Korschelt and Heider's embryology 324
—— Lake Urmi 315
—— Locomotion of Solenomya . 525
—— Mating instinct in moths . . 674
—— Otocyst of heteropods . . . 526
—— Pupa grafting in moths . . 236
—— Regeneration in grafted tissue 155
—— Regeneration in Reissner's fibre 316

PAGE

Parker, G. H. Sense organs of Nereis 328
—— Skeleton of Vulpes macrotis . 985
—— Skeleton of the black bass . 984
—— Synopsis of North American Actinaria 747
—— The neurone theory in the light of recent discoveries . 457
—— Vertebrate anatomy . . . 762
—— Villi of intestine 527
—— "Wilson's Cell" 761
—— Woods Holl Lectures for 1898 56
—— Woods Holl Lectures for 1899 759
Peabody, C. African masks and secret societies 973
Pearl, R. Recent work on electrotaxis 979
Peckham, G. W. and E. G. Instinct or reason 817
Pecten, Variation in 863
Pectinella, Variation of statoblasts in 959
Pedipalpi, Synopsis of 421
Peirce, G. J. Relations of fungus and alga in lichens 245
Pelomyxa 535
Peneus 327
Penhallow, D. P. Belzung's botanical anatomy and physiology . . 828
—— Coal measure plants . . . 80
—— Cretaceous plants 608
—— Fossil cycads 609
—— Fossil plants from Franz Joseph Land 610
—— Matonia 81
—— Medullosa 81
Pennaria, Natural history of . . 387
Petrographical notes . . . 161, 455
Petrography of Essex Co., Mass. . 453
—— Experimental 160
Petromyzon, Nesting habits of . . 617
Philippines, Vertebrates of . . . 436
Pig, Development of 913
Pine, Galls on 801
Planarians, Regeneration in . . . 173
Plankton of the Elbe 761
Porichthys, Lateral line of . . . 235
Pot hole near Catskill, N. Y. . . 33
Pratt, H. S. Synopsis of monogenetic trematodes 645
Prince Edward Island, Mammals of 483
Proboscidia, Limbs of 89
Projapyx 849
Protoplasmic streamings 434
Protoplasm, Structure of 322
Protozoan studies 824
Psychology of fishes 275
Puerto Rico, Fishes of 150
Pupa grafting in moths 236

PAGE

Rabbit, Variation in 639
Races of man 521
Rathbun, M. J. Cancroid crabs of North America 131
—— Synopsis of catometopous or grapsoid crabs 583
—— Synopsis of oxystomatous and oxyrhynchous crabs . 503
Reason or instinct 817
Regeneration in grafted tissue . . 155
—— in Medusæ 155
—— in Planarians 173
Rehn, J. A. G. Linnean genera Myrmicophaga and Didelphis . 575
Reissner's fibre 316
Reptiles, Vertebræ of 1
Retina of dogfish 236
Reviews:
Acloque's Fauna de France 602, 902
Alexander's Darwin and Darwinism 979
Andrews, E. A. Breeding Infusoria 328
Atherton's sense organs of worms 71
Atkinson's lessons in botany 607, 905
Bailey's cyclopedia of horticulture 335
Balfour on the musical bow . 429
Ballowitz, polytomous nerve fibres 63
Bancroft on tunicates . . . 71
Barker's nervous system . . 61
Barnes, Outlines of plant life . 905
Bauer's experimental petrography 160
Belzung's botanical anatomy and physiology 828
Berry on intestinal villi . . . 527
Bethe's intracellular canals of ganglion cells 762
Biological Bulletin 826
Blatchley's gleanings from nature 149
Bütschli on microstructure of crystals 978
Carlgren on electrotaxis . . 979
Clapp's lateral lines of the toadfish 235
Clements and Cutler's manual of high-school botany . . 989
Cohn on Uncinaria 72
Collett and Nansen's birds of the Norwegian Polar Expedition 417
Contributions from the U. S. National Herbarium . . . 74
Cooke on Easter Island . . 430

Reviews: PAGE
Cossmann's empirical teleology 822
Coulter's plant studies . . . 905
Cox's elementary physiology . 763
Cragin's our insect friends and foes 326
Crampton's pupa grafting . . 236
Cuénot's excretion in Mollusca 151
Cyclopedia of American Horticulture 767
Dana's wild flowers 988
Davenport's zoölogy 981
Dearborn's psycho-physiology of the crayfish 821
Delage on merogeny 982
Deniker's races of man . . . 521
Drew, Locomotion of Solenomya 525
Eigenmann on blind vertebrates 524
Evermann and Marsh on fishes of Puerto Rico 151
Fay's marriages of the deaf . 146
Fischer's tree toad 322
Flemming on the mammalian egg 320
Frazer's life of Cope . . . 819
Frobenius on African masks and secret societies . . . 973
Fur-seal investigations . . . 65
Garman's deep-sea fishes . . 663
Garrey's effects of ions on flagellate Infusoria 259
Geology of the Yellowstone National Park 770
Godelewski on multiplication of nuclei in muscle . . . 671
Gogorza's vertebrates of the Philippines 436
Graf's hirudineen studies . . 600
Greeley on tide-pool fishes . 233
Greene on caudal heart of hagfishes 666
—— Lateral line of toadfish . 235
Gunther's Lake Urmi . . . 315
Günther on fishes of Linné . 69
Häcker's mitosis following amitosis 236
Hague's tertiary volcanoes of the Absaroka Range . . . 156
Hargitt's experimental studies on Hydromedusæ 155
Harper's cell-division in Sporangia and Asci 448
—— Nuclear phenomena in Ustilagineæ 448
Hartmeyer's monascidians of the Bremer Expedition . . 765
Hedley's zoögeographic scheme for the Mid-Pacific 594

Reviews: PAGE
Heidenhain's protoplasmic streamings 434
Hill's management and diseases of the dog 598
His's protoplasm studies . . 322
Hoche's neurone theory . . 64
Holmes, Antiquity of man in California 145
Holzapfel's cephalopods of the Timan 830
Ilyin on otocysts of heteropods 526
James's practical agriculture . 906
Jenkins's labroid fishes of Hawaii 666
Jensen's eggs of hagfish . . 437
Jordan and Evermann's fishes 764
Jordan and Snyder on fishes of Mexico 667
Jörgensen's micro-organisms and fermentation 679
Karpinsky on Edestidæ and Helicoprion 579
Keeler's our native trees . . 988
Kennedy's beasts 314
Kerr, Development of Lepidosiren 670
King's irrigation and drainage 446
Kingsley on ear bones . . . 526
—— Vertebrate zoölogy . . 58
Kofoid on Platydorina . . . 331
Kölliker's reminiscences . . 232
Korschelt and Heider's embryology 324
Langdon's sense organs of Nereis 328
Lange's our native birds . . 321
Lankester's treatise on zoölogy 675
Lanier's "Bob," our mockingbird 320
L'Année Biologique for 1897 489
Loeb's artificial rhythmic muscle contractions . . . 150
Loman's distribution of Opilionidæ 597
Loomis on California waterbirds 440
Lonnberg on solpugids . . . 673
Lönnberg's lungless salamanders 437
Lyon on compensatory movements in fishes 669
MacDougall's nature and work of plants 605
Mackay's phenological investigations 445
Macmillan's Minnesota plant life 238
Maryland geological survey . 773
—— weather service . . . 772

Reviews: PAGE
Mason on Indian knives . . 431
Mayer's mating instinct in moths 674
McIntosh's resources of the sea 601
Meunier's experimental geology 772
Metcalf on nervous and glandular tissue in ascidians . . 766
Miller's (W. S.) contributions from the anatomical laboratory of the University of Wisconsin 762
Miller's (G. S.) mammals of New York 316
Miltz, Eyes of Polyphemidæ . 72
Minot on capillaries and sinusoids 527
Moore on Microbdella . . . 524
Morgan's regeneration in grafted tissue 155
Morris's man and his ancestor 593
Murbach's hydroids from Woods Holl 237
Nadiallac's unity of human species 313
Nathorst's fossil plants from Franz Joseph Land . . . 610
Neuville on formaldehyde . . 763
Newbegin's color in nature . 759
Newberry's later extinct floras of North America 79
Nicholson's dictionary of gardening 905
Parker's practical zoölogy . . 436
Payne's new world 231
Penard's growth in rhizopod shell 329
Penard's Rhizopoda of Lake Geneva 330
Pittard on ancient crania from the Rhone Valley 976
Prantl's Lehrbuch 606
Pratt's anatomy of sheep tick 327
Prowazek's protozoan studies 824
Quaintance's Aleurodidæ . . 825
Rand's hydra grafts 237
Report U. S. National Museum for 1897 430
Rhumbler, Physics of cell life 54
Rothamsted experiments . . 611
Roux's Swiss Infusoria . . . 329
Sargent on Reissner's fibre . 316
Sauvageau on Cutleriacea and alternation of generations . 678
Schaudinn on Arctic deep-sea fauna 442
Scheel, Sporulation in Amœba 332
—— Reproduction of Amœba 441
Scientific results of H. M. S. *Thetis* 825

Reviews: PAGE
Schorler, Plankton of the Elbe 760
Scott's Medullosa anglica . . 81
Seward's coal measure plants . 80
—— Matonia 81
Shufeldt skeleton of the black bass 984
—— osteology of Vulpes macrotis 985
Smith's New Jersey insects . 673
Smithsonian report for 1897 . 311
Smitt on Lycodes 439
Soulanes on measurements of human skeleton 312
Stöhr on duodenal glands . . 233
Temple primers 826
Thierreich Sporozoa 899
Thompson's (H. B.) nerve cells of the human cortex . . . 65
Thompson's (Seton) trail of the sandhill stag 319
Towle, Heliotropism of Cypridopsis 603
Trimen's flora of Ceylon . . 447
Tzwetaew's carboniferous cephalopods of Russia . . 831
Vernon's effect of staleness of sex cells on development . 823
Wagner's problem of innate ideas 822
Waite's fishes of the *Thetis* Expedition 438
Ward's cretaceous plants . . 608
—— fossil cycads 609
Ward, H. B. Garman's deep-sea fishes 910
Washington's rocks of Essex Co., Mass. 453
Wieland's fossil cycads . . . 609
Willem's circulation in Anodonta 154
Willey's Enteropneusta . . . 123
Wilson on prehistoric arrow-points, spear heads, and knives 43
Wilson's Cell 761
Woods Holl lectures for 1898 56
Woods Holl lectures for 1899 759
Woodward on Scapanorhynchus and Mitsukurina . . 234
Zittel's text-book of paleontology 681
Rhizopod, New 535
—— shell, Growth of 329
Rhizopoda, Abyssal 330
—— Reproduction of 441
Richardson, H. Synopsis of N. A. Isopoda 207, 295
Ritter, W. E. California water-birds 440

PAGE

Ritter, W. E. Monascidians of the Bremer Expedition 765
—— Nervous and glandular tissue in ascidians 766
—— Ovogenesis in tunicates . . 441
Roberts, H. F. Cell division in Sporangia and Asci 448
Robinson, B. L. Contributions from U. S. National Herbarium 74
Rocks of Essex Co., Mass. . . . 453
Russell, F. Deniker's races of man 522
—— Natural history of the musical bow 429
—— Report of the U. S. National Museum 430
—— Report of commissioner of education 432
—— Studies of cranial variation . 737

SALAMANDER, San Marcos . . . 179
Salamanders, Lungless 437
Sampson, L. V. Unusual modes of breeding and development among Anura 687
Sandalodus 581
Sargent, F. L. King's irrigation and drainage 447
—— McDougal and Trembly's experimental botany . . . 605
Scorpions, Synopsis of 421
Sea, Resources of 601
Sella turcica 434
Sense cells of annelids 71
Sense organs of Nereis 328
Sheep tick 327
Shufeldt, R. W. Onithological results of Nansen's expedition . 417
—— Psychology of fishes . . . 275
Simonds, F. W. Interpretation of unusual events in geological records illustrated by recent examples 495
Sinusoids and capillaries 527
Siredon 552
Slonaker, J. R. Abnormality in circulation of rabbit 639
Smith, F. Position of sacrum in Necturus 635
Smith, J. P. Holzapfel fossil cephalopods 830
—— Tzwetaew's fossil cephalopods 831
Solenomya, locomotion of . . . 525
Solpugids, Poisonous nature of . 673
—— Synopsis of 421
Sonorian zones 284
Species and subspecies 523
Specific gravity of animals . . . 95
Sporozoa 899
Sporulation in Amœba 332

PAGE

Stale sex cells and development . 823
Starfish, Growth and food supply in 17
Statoblasts, variation in 959
Syenites 453
Synopses of North American invertebrates:
VII. Cancroid crabs 131
VIII. Isopoda 207, 295
IX. Scorpions, solpugids, and Pedipalpi 421
X. Oxyrhynchous and oxystomatous crabs 503
XI. Catometopous or grapsoid crabs 583
XII. Monogenetic trematodes . 645
XIII. Actinaria 747

TABLET for museums 275
Teleology, Empirical 822
Teratological Loxosoma 891
Tertiary volcanoes of the Absaroka Range 156
Texan ants 563
Texas, Singular arachnid in . . . 837
Tide-pool fishes 233
Tilefish, Reappearance of . . . 68
Toadfish, Lateral line of 235
Tree toad 322
Trelease, W. Briefer courses in botany 905
—— Clements and Cutler's manual 989
—— Cyclopedia of horticulture, 335, 767
—— Dana's wild flowers 988
—— Keeler's our native trees . . 988
—— Nicholson's dictionary of gardening 905
—— Trimen's flora of Ceylon . . 447
Trematodes in frogs 811
—— Synopsis of 645
Trimerotropis, Variations in . . 471
True, R. H. Atkinson's "lessons in botany" 607
—— Prantl's Lehrbuch 606
Tunicates, Ovogenesis in 441
—— Vascular ampullæ of . . . 71
Typhlomolge 179

UNITY of human species 313
Ustilagineæ, Nuclear phenomena in 448

VAMPYRELLA 256
Variation in Daphnia 879
—— in circulation of rabbit . . . 639
—— in human crania 737
—— in Necturus 635
—— palæmonetes 621
—— in Pecten 863
—— in trimerotropis 471
—— in statoblasts of Pectinella . 959

PAGE

Venation in Tremerotropis . . . 471
Vertebræ of reptiles 1
Vertebrates, Anatomy of 58
—— Blind 524
—— of Philippines 436
Villi of intestine 527
Volcanoes, Tertiary of the Absaroka Range 156

Walton, L. B. Basal segments of hexapod leg 267
Ward, H. B. Excretion in Mollusca 151
—— Garman's deep-sea fishes . . 910
—— Note on cestode nomenclature 533
—— Reproduction of Amœba . . 441
—— Theirreich Sporozoa . . . 899
Wasp, Habits of 817
Wheeler, W. M. A singular arachnid in Texas 837
—— New myrmicophile 851
—— Texan ecitons 563
Williams, S. R. Specific gravity of fresh-water animals in relation to habits and composition . . 95
Wilson, H. V. A species of Pelomyxa 535
—— Marine biology at Beaufort . 339
Wolcott, R. H. Sheep tick . . 327

Yellowstone Park, Geology of . 110
Yerkes, R. M. Cossman's teleology 822
—— Dearborn's psychology of the crayfish 821
—— Heleotropism of cypridopsis . 603
—— Wagner's innate ideas . . . 822
Young, R. T. Mammals of Prince Edward Island 483
Young, R. T., and Cole, L. J. Nesting habits of brook lamprey 617

Zaitha, Genital organs of 119
Zapus 199
Zoölogical notes, 72, 156, 238, 322, 443, 527, 604, 676, 766, 827, 903, 986
Zoölogy of the Horn Expedition . 25

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A MONTHLY JOURNAL
DEVOTED TO THE NATURAL SCIENCES
IN THEIR WIDEST SENSE

CONTENTS

PAGE

I. **Intercentra and Hypapophyses in the Cervical Region of Mosasaurs, Lizards, and Sphenodon** . . HENRY FAIRFIELD OSBORN 1

II. **Arrangement and Preservation of Large Collections of Human Bones for Purposes of Investigation** . . . . ALÉS HRDLICKA 9

III. **On the Correlation between Growth and Food Supply in Starfish** A. D. MEAD 17

IV. **The Zoölogy of the Horn Expedition** . . . . . E. H. EATON 25

V. **A Glacial Pot-Hole in the Hudson River Shales near Catskill, N.Y.** HENRY FAIRFIELD OSBORN 33

VI. **The Visitors of the Caprifoliaceæ** . . . . . JOHN H. LOVELL 37

VII. **Reviews of Recent Literature:** *Anthropology:* Anthropological Notes — 53
General Biology: Physics of Cell Life, Biological Lectures — *Zoölogy:* 54
Kingsley's Vertebrate Zoölogy, A New Text-Book on the Nervous System, 58
Neurone Theory, Polytomous Nerve Fibres, Nerve Cells of the Human Cortex, The Fur Seals and Fur Seal Islands, Fishes of the Potomac River, The Reappearance of the Tilefish, The Nervous System of the Bony Fishes, A Filefish New to the United States, Fishes of Kadiak Island, Fishes of the Congo, Fishes of Florida, Günther on the Fish Collections of Linnæus, Meek on the Fishes of Lake Muskoka, Function of Vascular Ampullæ in Composite Tunicates, Sense Cells in the Integument of Worms, The Eyes of the Polyphemidæ, Zoölogical Notes —
Botany: The Last Contribution from the U.S. National Herbarium, 74
Bailey's Botanizing, Botanical Notes — *Paleontology:* The Later Extinct 79
Floras of North America, Coal Measure Plants, Matonia pectinata, Medullosa anglica

VIII. **News** 83

IX. **Publications Received** 86

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INTERCENTRA AND HYPAPOPHYSES IN THE CERVICAL REGION OF MOSASAURS, LIZARDS, AND SPHENODON.

HENRY FAIRFIELD OSBORN.

In the course of a recent study of the skeleton of Mosasaurs[1] I was much struck by the uncertainty which prevails in the interpretation of the elements entering into the vertebræ of the neck. The leading American authorities, Cope, Baur, and Williston, differ widely in their descriptions of these parts in different papers. The late Professor Baur himself had a perfectly correct notion of the components of the neck, as I learned from him in conversation; but a clear statement of his views is not to be found in his published writings. Two of the leading German comparative anatomists, Gegenbaur and Wiedersheim, fail entirely to recognize clearly the very interesting structure of the cervical vertebræ. I was thus led to the comparison of the neck vertebræ in different members of the Squamata and Rhyncocephalia, with most interesting results.

It appears that *intercentra are present in the neck of all*

[1] A Complete Mosasaur Skeleton, Osseous and Cartilaginous, *Mem. Amer. Mus. Nat. Hist.*, vol. i, pt. iv. October, 1899.

Mosasaurs, lizards, and Sphenodon, either in a primitive position or secondarily modified to subserve a variety of functions.

The best known modification is in the atlas, where the intercentrum forms the base of the ring. The modifications which have not been so generally recognized are in the axis and the other cervicals, where the intercentra secondarily function as *hypapophyses*, while still remaining more or less distinct from the centra proper.

The primitive relations of the intercentra and pleurocentra (or centra proper) in the axis and atlas are beautifully shown in

Fig. 1. — *Platecarpus coryphæus* Cope, Coll. American Museum Natural History. Atlas, 1; axis, 2; third cervical, 3. Right neural arch, *n.a.*, in place; left neural arch removed, exposing odontoid (supposed pleurocentrum of atlas), *od.* loosely articulated with axis. Intercentrum of atlas, *i.1*; intercentrum of axis, *i.2*; intercentrum of third cervical, *i.3*; intercentrum of fourth cervical, *i.4*. Intercentra 3 and 4 are secondarily shifted forward upon the hypapophyses of the centra in front.

the accompanying photograph (Fig. 1), taken from the neck of a specimen of Platecarpus — one of the Kansas Mosasaurs. But before describing this it will be well to recapitulate.

The prevailing interpretations of the neck components in different types of reptiles are as follows:

1. *Proatlas.* The pair of small dorso-lateral elements in Rhyncocephalia (see Fig. 4, *D*), certain Lacertilia, Crocodilia,

Dinosauria, Pterosauria, Chelonia, are regarded by some authors as vestiges of a "proatlas" or degenerate vertebra between the atlas and the skull. As remarked by Baur, these pieces correspond in position with the "neurapophyses" of a typical vertebra.

2. *Atlas.* The lateral pieces of the atlas proper are by all authors regarded as neural arches or "neurapophyses" (*n.a.* in our figures).

3. *Atlas.* In his early papers Cope — in fact, when he first defined the "intercentrum" — regarded the ventral pieces of atlas and axis as "intercentra" (*i.1* and *i.2* in our figures). The

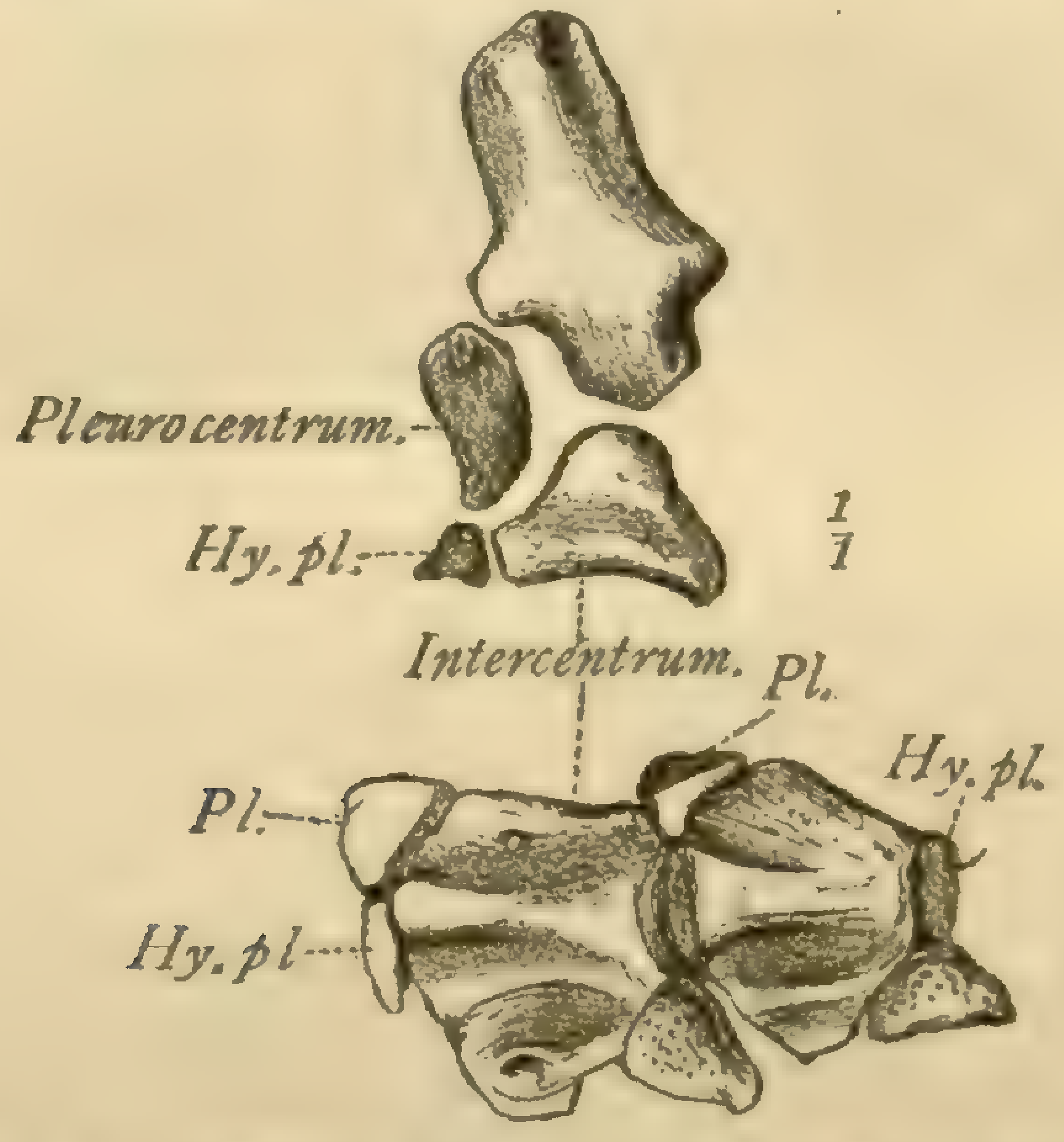

FIG. 2. — *Chelydosaurus vranii* Fritsch. A rachitomous amphibian vertebra from the Permian of Bohemia, viewed from the *right* side, after Fritsch. Neurapophyses, neural arch, 2 pieces; pleurocentra, on sides of notochord, 2 pieces; hypocentrum pleurale, below notochord, 1 piece; intercentrum arcale, below notochord, 1 piece.

anterior ventral piece (*i.1*), or lower element of the atlas ring, is, however, described as a "centrum" (*i.e.*, "pleurocentrum") by Baur in his latest paper; by Gegenbaur as possibly an "hypapophysis" (*Vergleichende Anatomie*, 1898, p. 249). In an unpublished lecture chart Baur rightly interprets ventral pieces of both atlas and axis as "intercentra."

4. *Axis.* The odontoid process is regarded as the pleurocentrum or centrum proper of the atlas, which has become secondarily attached to the axis (*od.* in our figures).

5. *Axis.* The posterior ventral piece (*i.2* in our figures) is described as an "intercentrum" by Baur, as the "atlantar hypapophysis" by Williston, in the Mosasaurs.

6. *Cervicals 3–9.* The ventral intermediate pieces (*i.3* to *i.8* in our figures) are spoken of as "intercentra," also as "hypapophyses."

I. RACHITOMOUS PROTOTYPES.

For the origin of these structures we must naturally turn back to extinct forms, and we find two rachitomous prototypes — one composed of six pieces, one of five.

Among the primitive Amphibia (Stegocephalia) we find types in which every vertebra is composed of six pieces, as figured by

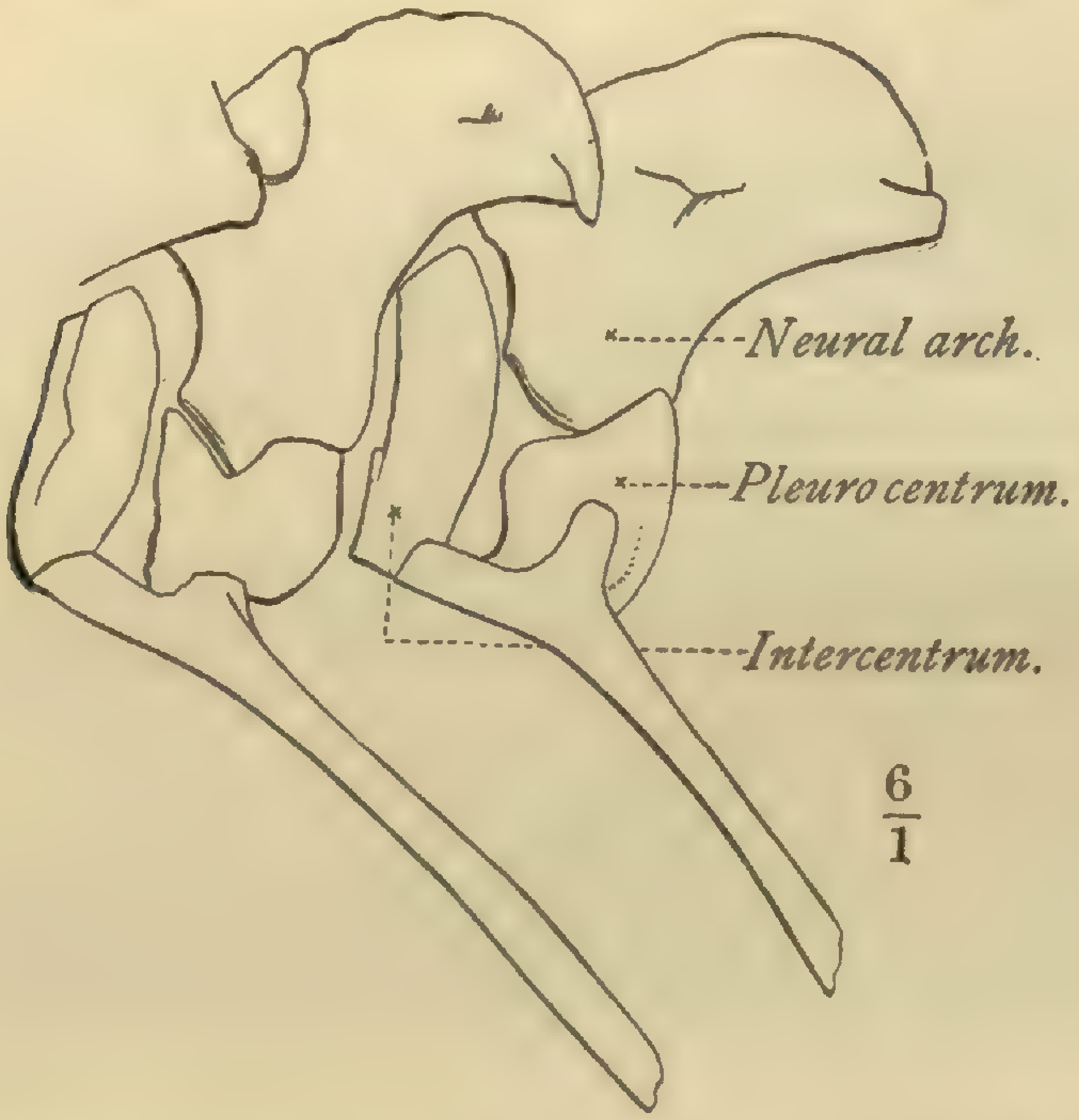

FIG. 3. — *Discosaurus* Credner. A rachitomous amphibian vertebra from the Permian of Saxony, viewed from the *left* side, after Credner. Neurapophyses, neural arch, 2 pieces; pleurocentra, lateral, 2 pieces; intercentra, median ventral, 1 piece.

Fritsch, Fig. 2 (*Chelydosaurus vranii*). It is possible, therefore, that the "proatlas" may represent, not a separate vertebra, but part of the atlas of a persistent rachitomous type.[1] This is improbable.

[1] According to this hypothesis, *for which at present little can be said*, the homologies would be as follows:

Atlas Components.	*Secondary.*
Primitive neurapophysis	= proatlas.
Primitive pleurocentrum	= neural arch.
Primitive intercentrum	= base of atlas ring.
Primitive hypocentrum pleurale	= odontoid process.

The demonstration of a vestigial, anterior, cervical nerve belonging to the degenerate "proatlas" vertebra would be fatal to the above hypothesis.

A likelier rachitomous prototype is that afforded by Discosaurus Credner, another Stegocephalian, in which it is seen (Fig. 3) that the intercentrum is in front of its corresponding pleurocentrum or centrum. Such a vertebra consists of five pieces. If from such an atlas prototype the pleurocentrum (*pl.*) were to be transformed into the odontoid process, the first result

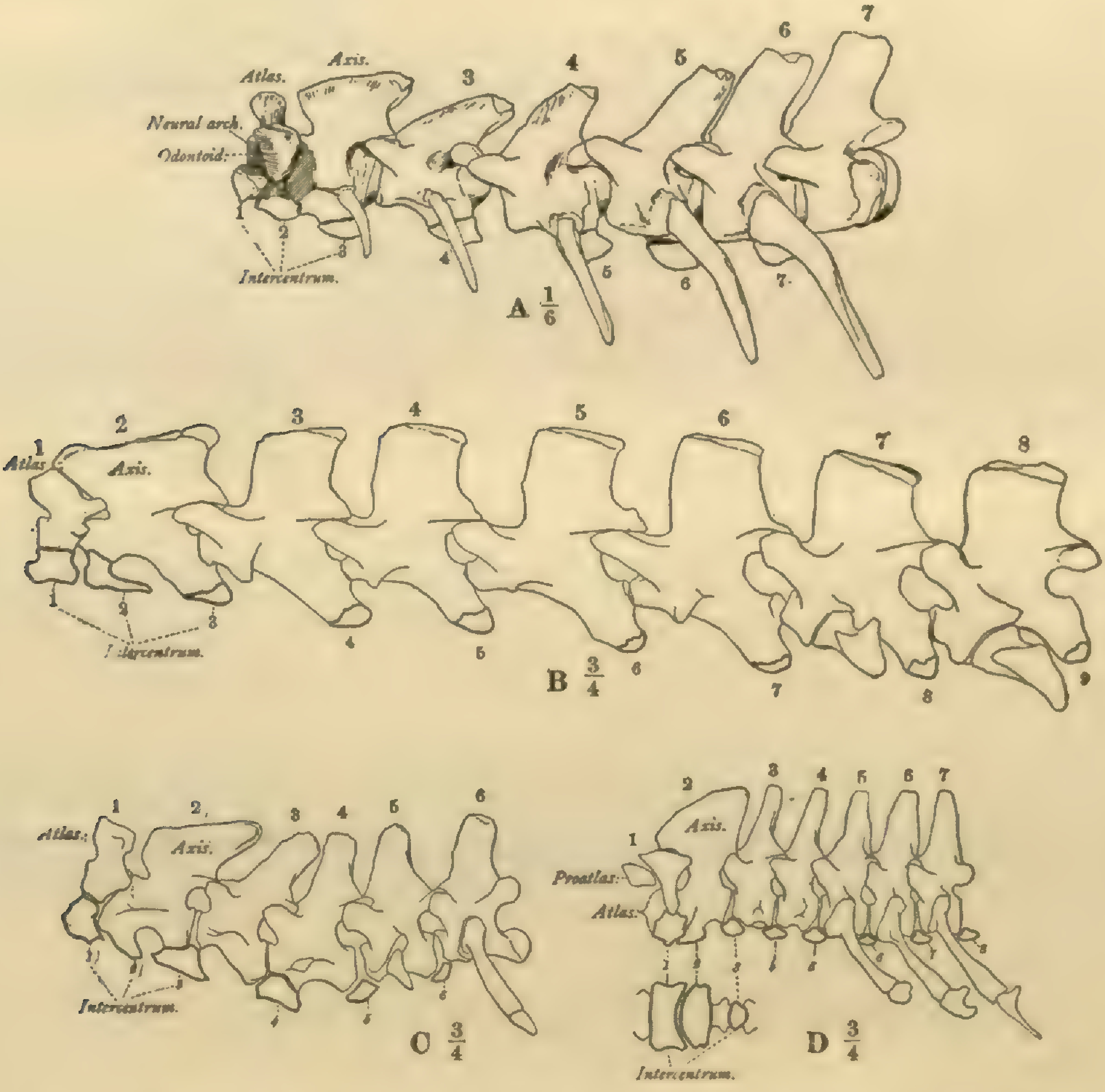

FIG. 4. — Typical cervical vertebræ of Mosasaurs, lizards, and Sphenodon. *A*. Platecarpus, a Mosasaur, with left neural arch of atlas removed. *B*. Varanus, a monitor lizard, with intercentra secondarily shifted to tips of hypapophyses. *C*. Cyclurus, a lizard, with intercentra in *primitive position*, excepting *i.2*, which has been shifted backwards and coalesced with hypapophysis of axis. *D*. Sphenodon, a Rhyncocephalian, with all intercentra in primitive position, excepting *i.2*, which is coalesced with axis, as in Cyclurus.

would be to bring the atlas and axis intercentra together without change of form. This is exactly what we find in Platecarpus, one of the Kansas Mosasaurs (Fig. 1). The photograph represents a condition in which the intercentra 1 and 2 are alike in their wedge-shaped form, and are still entirely free from the other elements of the atlas and axis (see also Fig. 4).

2. Conditions in the Mosasaurs, Lizards, and Sphenodon.

The modifications of the primitive type, in which each centrum has an intercentrum below and in front of it, are well illustrated in the accompanying diagrams (Fig. 4).

The condition of the Platecarpus axis and atlas is even more primitive than that of Sphenodon; but Sphenodon is more primitive than Platecarpus in the vertebræ behind the axis.

A. In Platecarpus both atlas and axis intercentra free and wedge-shaped. Intercentra 3–7 shifted forward secondarily upon the short hypapophyses of centra 2–6.

D. In Sphenodon a "proatlas"; intercentrum 1 of atlas loosely connected with neurapophysis of atlas; intercentrum 2 of axis completely coalesced with axis; intercentra 3–7 in their primitive position.

B. In Varanus intercentrum 1 broadly connected with atlas neurapophysis; intercentrum 2, forming an anterior hypapophysis upon axis, loosely connected in young, suturally united in adults; intercentra 3+ forming tips of the long hypapophyses of centra 2+. (This hypapophysial connection of the intercentra is an advance upon that initiated in Platecarpus.)

C. In Cyclurus intercentrum 1 broadly united with atlas ring; intercentrum 2 completely coalesced with axis; intercentra 3 and 4 in primitive position, but expanding to function as hypapophyses; intercentra 5 and 6 small, in primitive position.

The secondary modifications have, therefore, been of four kinds:

1. Conversion of the atlas intercentrum 1 into the basal piece of the atlas ring by loss of its wedge-shape and broadening of its contact with the neurapophyses (*e.g.*, Varanus, Cyclurus).

2. Lateral or complete union of the axis intercentrum 2 with the anterior portion of the axis centrum (*e.g.*, Cyclurus, Sphenodon).

3. Secondary conversion of the intercentra 2+ into hypapophyses (*e.g.*, axis of *B*, *C*, *D*; axis and third cervical of Cyclurus).

4. Shifting of the intercentra 3–7 forward upon the hypapophyses of the preceding vertebræ (*e.g.*, Varanus, Platecarpus).

This history of the atlas and axis complex in the Mosasaurs, lizards, and Sphenodon may, in conclusion, briefly be summarized as follows :

1. The intercentrum of the atlas fuses with the neural arches of the atlas to form the basal portion of the ring.

2. The intercentrum of the axis fuses with the centrum of the axis to form a kind of hypapophysis.

3. The intercentra of the remaining cervicals 3–7 either remain primitive in position, or are shifted forward upon the hypapophyses of the next vertebra in front.

American Museum of Natural History,
December 7, 1899.

ARRANGEMENT AND PRESERVATION OF LARGE COLLECTIONS OF HUMAN BONES FOR PURPOSES OF INVESTIGATION.

ALËS HRDLICKA.

SINCE my mention, nearly a year ago,[1] of a definite method in the care of bones which are to be utilized for investigation, I have received several inquiries as to the details of such a method. As the subject is not without importance, I think it will be useful to bring the particulars to the general attention of the anatomists.

My practical experience with bones was gained principally in the anatomical department of the College of Physicians and Surgeons, New York, and in the American Museum of Natural History, the same city; besides this, I had a chance to make observations on a number of large anatomical, anthropological, and zoölogical bone collections both here and abroad.

The remarks which follow apply only to collections of human bones, in fact, principally to large (established or prospective) collections of the bones of whites. They apply further only to a general method of the care of bones, which will easily allow any especially desirable exceptions by individual investigators, such as the treatment of the whole spinal column (Dwight), pelvis, etc.

For small collections, for anthropological and zoölogical collections of bones, probably the best general rule is to keep, in appropriate series, all the bones of each skeleton together, minus the skull. Each bone should bear the number of the skeleton. The skulls of the same tribe of people or species of animals are kept together, heading the series. Each distinct group of skulls and skeletons in a collection is divided and arranged in at least three groups: the children or young,

[1] Before the Association of American Anatomists, New York, December, 1898, paper on Tibia.

and grown individuals, separated into males and females. In large series the embryos, adolescents, and very old may be advantageously separated from the others. The best way to preserve these collections is in tiers of sliding shelves or drawers. The anthropological collection as a whole is arranged on the basis of race and type, and further subdivided according to the geographical distribution. A zoölogical collection is naturally best arranged on the basis of the grade of evolution of the animals. This rule may be followed from the most comprehensive zoölogical subdivision to individuals.

The method of arrangement in large collections of human bones of a comparatively homogeneous character, such as the bones of whites, when the object of these collections is to be a possibility of a thorough investigation on the bones, must differ from the above.

Anatomy is past the stage of study of single normal bones, just as it is past the stage of study of any single normal organ in the body. The present and future anatomical investigations can only deal with large numbers of specimens. The points which are to be settled by the investigations concern, in the first place, the regular changes or life history of each individual bone. We are further to learn the prevalent types of each bone and their meaning; to complete our knowledge of the more primitive, recurrent, and anomalous, and define the prospective characters of each bone; and to establish the influences on the various bones of recent as well as hereditary, normal, and abnormal characters.

In order that such studies may be possible, all the bones in our collections must, in the first place, be *identified;* in the second place, they must be *supplemented with certain data on the subjects from which they proceed;* and in the third place, the bones must be so *stored as to present the utmost facility for any study desired.*

So far no osteological collection of which I have any knowledge comes fully up to the stated requirements; the collection that comes nearest to the desired standard is in all probability that of Prof. Geo. S. Huntington, in the College of Physicians and Surgeons, New York City. However, as the value and

promises of advanced investigation on bones will receive, which they cannot fail to do, a more thorough appreciation by the teachers and students in anatomy, old bone collections will increase and new collections will be established, and both these effects should take place only on the basis of the most approved principles.

Such were the considerations which led me in formulating, during the last four years, the system of care of bones, which follows. Every point advocated I had the occasion to test or observe in practice, and only that is included which is simple, practical, and essential for investigation. Some of the details which at first may seem superfluous will be appreciated later by the student of the collection. The method once tested under different circumstances in practice will undoubtedly be found capable of advantageous modifications, but I think it will, in general, prove sufficient for the beginning of a collection. . . .

The *care of bones*, when their full scientific utilization is in view, should begin at the reception of the body in the anatomical department.

It is very advisable, on receiving the body, to ascertain the following points, namely: color, sex, age, nationality (if American, the nationality of parents in addition), and last disease; also the principal (not necessarily the last) occupation of the individual in his life.

In all accidental or sudden deaths the weight of the body, with a note as to loss of blood, should be taken.

A few selected, simple measures of the body[1] and head are very desirable.

All the data, if *carefully* obtained, will serve as valuable bases for future studies and comparisons on the skeleton.

It is best that one of the permanent associates in the anatomical department of a college should be given the care of all these preliminaries.

[1] Length of the body: middle of the soles to vertex; maximum length and width of the head, with its height from biauricular line; antero-posterior and lateral diameters of the chest, at the level of the sternal articulation of the third ribs and at that of ensiform cartilage. Vertex-coccyx length is also a desirable measure.

All records should be preserved in a special book. Each case receives its number; it is best to carry the numbers on consecutively, for that will, among other advantages, facilitate references.

The number a body has been given and the year when received, are stamped indelibly on a card, and this is so attached to the body as not to be lost. When the body comes on the dissecting table, various means may be used to keep the subject identified. In all cases it is well to preserve the original card secured in some way at the table.

While the body is being dissected, care must be exercised that the different parts are not displaced. As soon as any long bone, or the scapula, or innominatum, sacrum, lower jaw or skull, is finished with, it should be the duty of some one in the dissecting room to attach by wire a little metal tag to it, with stamped-in number of the subject (zinc, or zinc-lead alloy wire and metal are to be used; steel wire will not last, while copper wire will color the bone).

All the short bones of each group (hand, foot, sternum and ribs, vertebral column) are placed into a small-mesh zinc wire cage, or into a small net (which latter, however, should be strong enough to resist boiling or maceration), and to each cage or net a similar metal tag is appended as to each larger bone.[1]

The tags are to stay on all the bones to which they were attached individually. On the short bones, when prepared and dried (which latter should be done with the bones still in their sacks or cages), the number of the subject is placed in indelible ink.

Chemicals should be avoided in the preparation of bones for study, as they affect the bone weight and specific gravity, both valuable points for investigation. Too long boiling is also injurious, particularly to the bones of the young or old.

The problem of *storing* prepared and marked bones is of considerable importance. It presents several distinct points to which attention must be directed, namely: (1) the bones should be stored so as to be protected against dust, sunlight, and

[1] System successfully used at the College of Physicians and Surgeons, New York.

great changes of temperature or moisture, and occasionally also against insects or rodents ; and (2) the bones should be stored in such a way as to be readily and easily accessible and offer the utmost facilities for study or exhibition, as well as an ease of proper replacement. These desiderata can be accomplished as follows:

1. A fairly well lighted, dry room is lined with shelve frames, or drawer frames. Other similar frames can be placed across parts of the room when necessary. The frames are so arranged that the drawers or boxes which are to be placed in them can slide in and out (this can be arranged quite simply and inexpensively). The size of the frames is determined by the size of the boxes or drawers, which must be of two or three dimensions. A very good preventive against insects, or even rodents, is a little of paris green mixed with some sugar and flour.

2. For the small bones it is best to provide light boxes just a little larger than necessary to contain their groups (speaking of adults). Low partitions (potter's clay) in these boxes would enable us to subdivide each group of small bones and much facilitate their study. A definite number of coverless boxes fit into a drawer, on which are plainly and indelibly marked the character and number (*x–x*) of the contents. It is best to have the drawers just large enough to accommodate the boxes with all the small bones of each individual skeleton, and to keep these bones permanently together.

The long bones may be stored in two ways, each of which has certain advantages.

All the long and other bones of the skeleton, remaining after the disposal of short bones as outlined above, minus the skull and lower jaw, can be placed together in a special drawer, which can then be placed, properly marked, next the drawer with the short bones of the same skeleton. Thus, all the bones of each skeleton, minus the skull, which can easily be found, are kept close together.

When very large series of bones are to be studied, the following method of storage is preferable: More spacious drawers are provided; or there may be simply shelves with closed

compartments, each of which has a door that ought to open downward. The bones are stored into these compartments according to the kind and side, and in series of consecutive numbers. Each large bone in the body has its own section of the shelves. The size of each section may be calculated on the basis of the space necessary to accommodate five hundred, one thousand, or a larger series of specimens. The kind and numbers (*x–x*) of bones are marked in this case (because changes will take place in the number or quality of the exact contents, *v.* below) preferably on cards, which are nailed or otherwise attached to the drawers.

The skulls, including lower jaws, it is best to store separately, in drawers accommodating a certain number each, and carrying in a prominent place a record of their contents.

So far for simple *preliminary* storing. The next step in arranging a large bone collection is the separation of each series of bones into three subseries, containing the normal, pathological, and anomalous bones.

The normal bones should be further subdivided according to sex (which is also applicable to the other subseries, if large). A still further advantageous subdivision of the series of bones, but only in the largest collections, is that based on racial (nationality) character of the bones.

The bones of children, and those of negroes (unless plentiful) and rare subjects, are best kept separately, a large box being provided for each skeleton.

When an anomalous or pathological bone or bones are removed from a series, a card should be kept with the series of the location of the specimens.

To complete the value of a bone collection, a card catalogue is a necessity. This may be conducted with various degrees of thoroughness. The simplest catalogue is that where each skeleton receives one card, on which are stated the history of the body (copy of the record made before dissection) and the main pathological or anomalous conditions observed on the skeleton. The ideal and most complete catalogue would be that where *each bone* would receive a card, which would bear its special characters and its dimensions.

The arrangement of specimens for *exhibition* differs much from that for storage. It should be based on at least two principles, namely: The normal bones should be arranged in series showing all their variations, the pathological and anomalous bones in series showing as many grades or steps as possible in the evolution of their specific characters. The series are arranged according to the order in which the bones of the human body are generally treated in anatomical works or lectures. Wherever possible, the series should be supplemented by casts or pictures and by specimens from lower mammals, fit for comparison. Explanatory labels with references, and, if possible, with a special card catalogue for the museum, complete the value of the exhibitions.

NEW YORK, 106 East Seventy-first St.

ON THE CORRELATION BETWEEN GROWTH AND FOOD SUPPLY IN STARFISH.

A. D. MEAD.

In the higher vertebrates there is a pretty constant relation between the age of an individual and its size, at least up to the time when the full stature is reached. This relation is expressed in carefully constructed curves of growth, and it may be inferred from common observation. The healthy individual must be able, during its early life, not only to hold its own in respect to size, but also to grow; the time between meals must be comparatively short, and the nourishment assimilated must be more than sufficient merely to replenish waste tissue. Minot has shown for guinea pigs that even "any irregularity in the growth of an individual tends to be followed by an opposite compensating irregularity." "If an individual grows for a period exceedingly fast, there immediately follows a period of slower growth; and, *vice versa*, those that remain behind for a time, if they remain in good health, make up the loss (at least in great part if not always completely) soon after." "Each individual appears to be striving to reach a particular size" — a particular size, we might add, not only for the adult age but for any particular previous age.

The normal rate of growth of marine invertebrates seems not to have received much attention, and were one to inquire among longshoremen or seaside naturalists how old an eight-inch lobster is, or how long it takes a starfish to grow to a certain size or to become sexually mature, he would meet with an interesting variety of opinions and receive little satisfactory information.

Several years ago Alexander Agassiz made an estimate of the rate of growth in starfishes, which was based upon the supposition that a close relation does obtain between size and age in these animals as well as in vertebrates. The method which he

employed was previously used by the elder Agassiz for ascertaining the age of many marine animals (*Proc. Essex Inst.*, 1863), and is explained in the following quotation from the monograph on North American starfishes:

"The young starfishes figured on this plate (Pl. VIII) were all found attached to roots of Laminaria thrown up on the beaches in the neighborhood after a storm; and from their different stages of growth, as compared with the oldest starfish raised from a brachiolarian (Pl. VI, Fig. 11), specimens of which were also found upon these roots, it is probable that the sizes here figured are one (Fig. 1), two (Fig. 8), and three (Fig. 10) years old. A considerable number of specimens were picked up in this way, and they could all be arranged into very distinct groups, representing the starfishes of the present and two previous seasons. There seemed to be no gradation from one group to another, such as we have among the young sea urchins, which, in consequence of their manner of breeding during the whole year, form series the relations of which it is impossible to determine. In this connection I would say that, by arranging the starfishes found upon our rocks into series according to their size, we are able to obtain a rough estimate of the number of years required by them to attain their full development; this I presume to be somewhere about fourteen years. They begin to spawn before that time, as specimens have been successfully fecundated which evidently were not more than six or seven years old."

During the summer of 1898 the writer had an excellent opportunity to study the rate of growth of the starfish (*Asterias forbesii*) at a floating laboratory moored in one of the estuaries of Narragansett Bay. The breeding season was short and definite, and the larvæ began to "set" the last of June.

On June 29, innumerable young starfish, about as large as the head of a pin, were discovered clinging to the eel-grass and to the rockweed and other algæ, where a few days before none could be found. A handful of the fluffy seaweed, *Heteromorpha*, bespangled with minute stars, was placed in a floating car, whose sides were encrusted with a young growth of barnacles, fresh fronds of green algæ, and delicate branch-

ing stalks of hydroids. That the little starfish found here a natural and congenial environment was evident from their healthy appearance, their quick response, and their rapid growth.

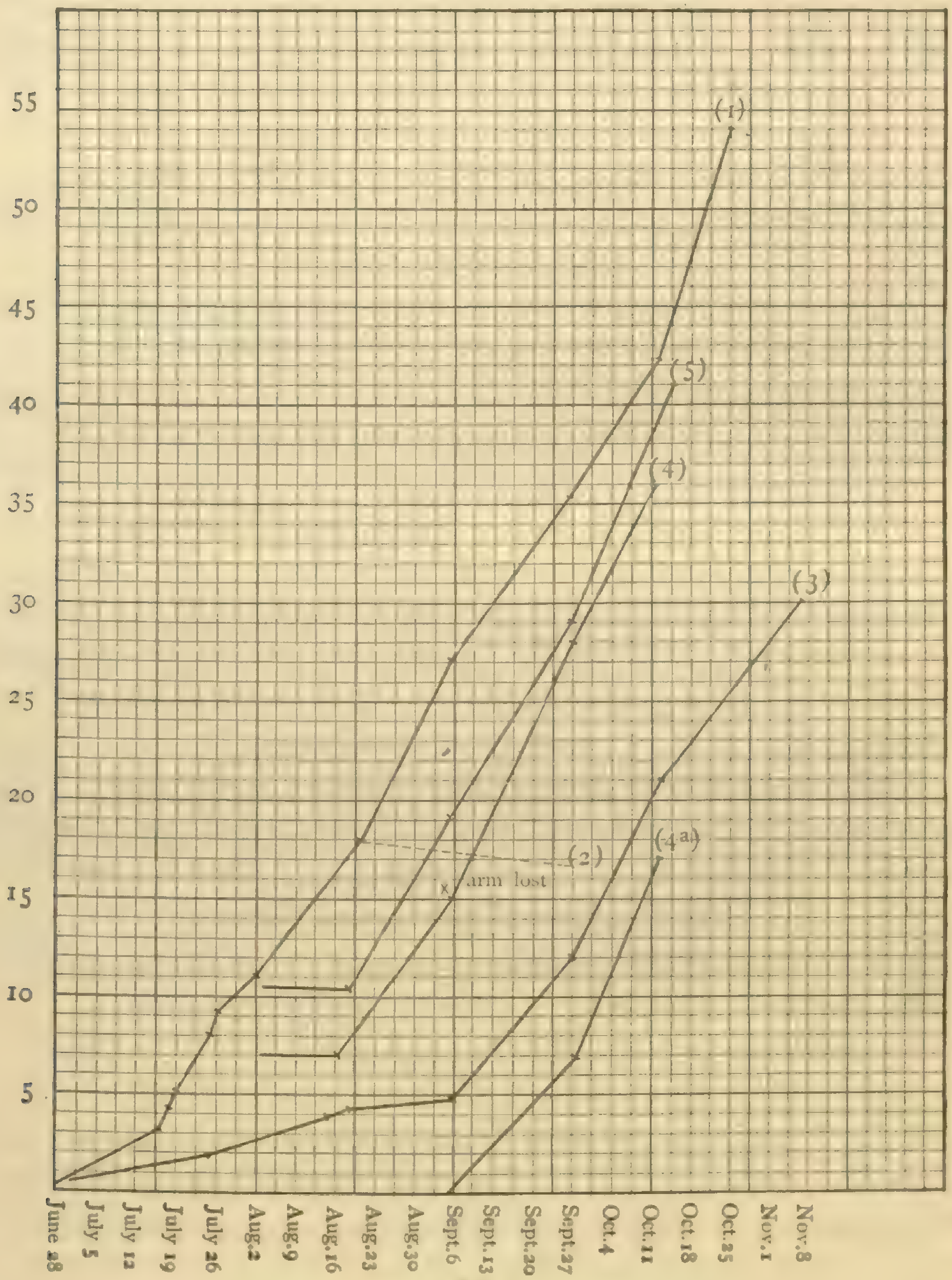

Fig. 1.

They were kept under observation until November and fed on barnacles, small clams, and mussels. As they were examined from time to time, two features of their growth were especially noteworthy, *viz.*, its rapidity and the difference in rate in

different individuals. On June 29 none of the stars measured more than 1 mm.;[1] on July 18 one of the larger specimens measured 5 mm.; July 26, 9 mm.; August 18, 18 mm.; September 26, 35 mm.; October 25, 54 mm. (over 2 inches). Curve 1, Fig. 1, is a graphic representation of the growth of these stars and is constructed from measurements of the largest specimens which could be found in the car at each observation. At any time after the first few weeks some of the specimens were three times as large as others, and between these all intermediate stages could be found. On August 18, for instance, eight specimens, arranged according to their sizes, measured 7½, 8½, 10½, 12, 13, 14½, 16, and 18 mm. A similar series — or a more perfect one — might at any time be arranged from specimens taken along the shores.

From the fact that in starfish of the same age such great differences in size exist, with all gradations between the extremes, it is evident that there is danger in applying to them Agassiz's method of ascertaining age. Indeed, the specimens which were calculated by him to be three years old were not one-fifth as large — linear measurement — as those known by actual observation to be only three months old.

Coming now to the consideration of the conditions which determine the *difference* in the rate of growth in these animals, we may exclude certain factors at once; for example, the influence of light, temperature and density of the water, and size of containing vessel, inasmuch as these conditions are practically the same for all the individuals under observation.

It appears from some other experiments, however, that difference in the amount of food is the principal, if not the only, factor. The starfish differs from the higher animals in this important respect; it can eat and *assimilate* many times as much food as is necessary merely to maintain a healthy condition. When food is accessible, the starfish eats voraciously and grows with great rapidity; but, on the other hand, it will live for months almost without food and apparently remain healthy, though it does not grow. As one watches a large

[1] All the measurements given below as "length" are from the mouth to tip of arm.

number of stars of the same age and size, transferred to a new car, he will not fail to notice that some of them happen upon a favorable food supply before the others, and in consequence grow at first much faster than the rest. Then, not only do these larger specimens have the better chance of getting food, but, if the animals usually preyed upon become scarce, the larger starfish do not hesitate to devour the smaller ones. It was noticed repeatedly that the variation in the rate of growth was much greater among the starfish whose food supply was limited than among those abundantly provided for. The immediate effect upon the rate of growth of the supplying and the withholding of food is demonstrated in the following experiments.

One of the starfishes in the car which had grown most rapidly up to August 18, when it measured 18 mm. (see curve 1), was kept until September 26 with very little to eat. During these five weeks there was no growth in this specimen (curve 2), but rather a slight decrease, although the largest specimen left in the car had doubled its length.

Another small starfish (curve 3), which was caught in the tow net as a brachiolarian and "set" in the aquarium on June 28, was kept on a very small allowance of food until July 23, when it measured 2 mm. It was then fed occasionally on small barnacles, and on September 6 measured 5 mm. After this it was given an abundance of food, with the following result: September 26, 12 mm.; October 12, 21 mm.; November 5, 30 mm.

Several other starfish which were caught in the tow and set in an aquarium at the same time with the last were kept on a small allowance until September 6, and were then apparently in good health, although they had grown but little. Fig. 2 *A* represents one of these at the age of about five weeks, and Fig. 2 *B* represents a well-nourished specimen of the same age, taken from the car.

Two specimens (curves 4, 5) of medium size, 7 mm. and 10½ mm., respectively, were transferred, on August 3, from the original car, where they had been reared on barnacles, to an adjacent car. They were supplied with a bunch of

small mussels, which, however, the starfish could not or would not open, and on August 16, after a period of thirteen days, they had not grown at all. From this time they were provided with an abundance of their usual food — barnacles — and grew with great rapidity, as is indicated in the curves. On November 12 they measured, respectively, 36 and 41 mm.

Incidentally curve 4 shows another interesting point, namely, that the loss of an arm does not cause a diminution in the rate of growth. On September 5 an arm was accidentally torn off, yet the rate of growth of the rest of the body was as rapid as

Fig. 2 *A*.

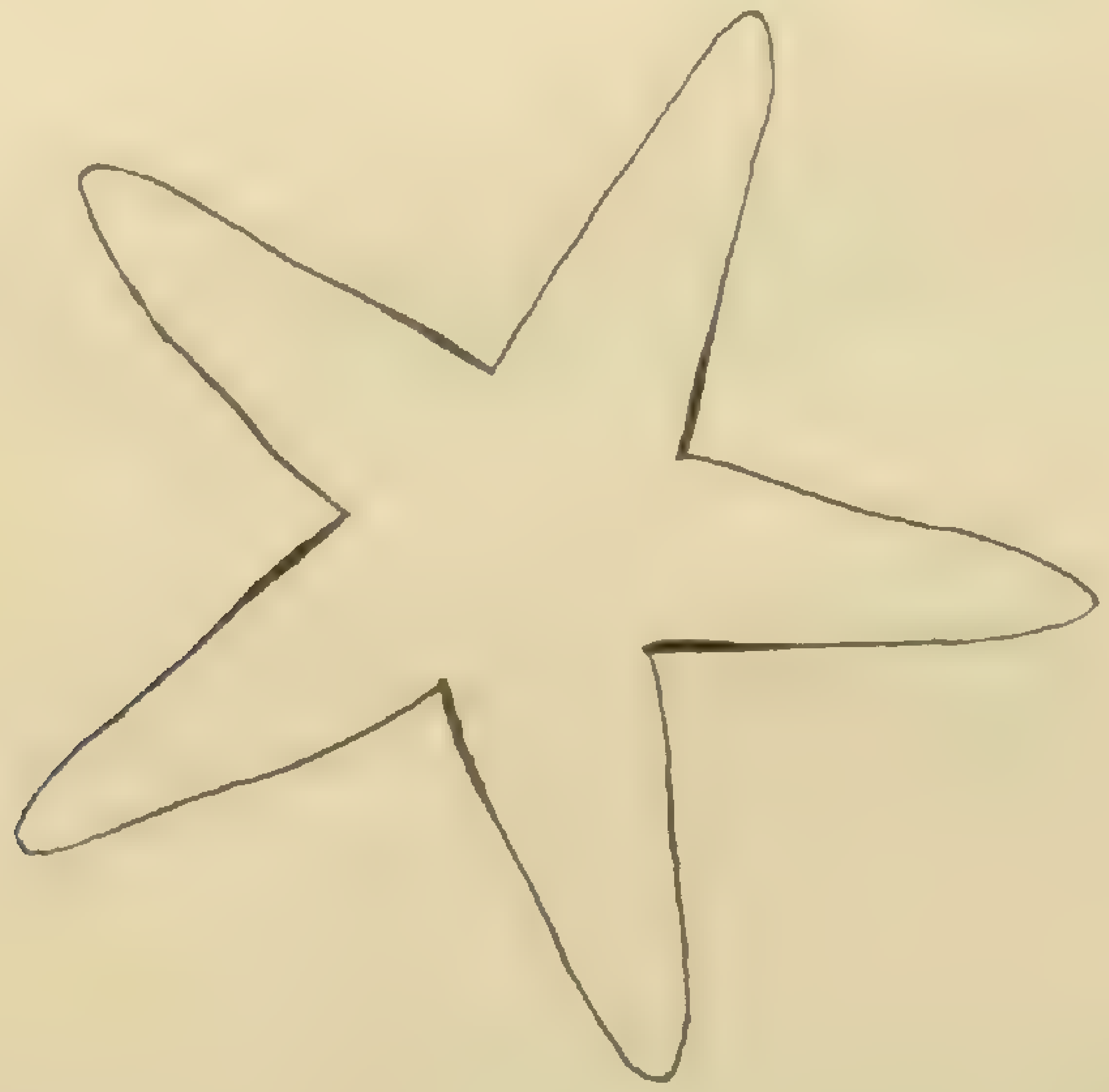

Fig. 2 *B*.

These figures represent two starfishes of the same age (5½ weeks).

before, and as rapid as that of the other starfish (curve 5). The rate of growth in the regenerating member is indicated in curve 4 *a*.

The age at which the starfish becomes sexually mature also depends upon the rate of growth; in other words, a starfish must attain a certain size before it may become sexually mature. During May, the month preceding the breeding season, nearly all the starfishes measuring over 50 mm. (2 inches) are full of ripe sex products, and occasionally ripe specimens are taken which measure only 32 mm. Larvæ have been obtained by artificial fertilization from parents measuring 38 mm. Now many of the starfishes raised in the car were considerably more than 38 mm. in length on October 25, three months after

setting, and their sex glands were quite as well developed as they were in the average stars of any size at that season of the year. Allowing the very moderate estimate of 15 mm. for the growth of such individuals during the next six months, in May they would be more than 50 mm. in length, and such specimens are, with rare exceptions, sexually mature. We are warranted in inferring, therefore, that well-nourished starfishes arrive at sexual maturity and breed before they are a year old.

On the other hand, it is evident that many starfishes do not reach sexual maturity in one year, since small, immature specimens, between 10 and 20 mm. in length, are not uncommon just before the breeding season begins.

Desultory observations on other marine invertebrates, *e.g.*, the clam, oyster, and lobster, indicate that the conditions of their growth are essentially similar to those of the starfish, and to this extent substantiate the conclusion that between the higher and lower animals there are fundamental differences in the phenomena of growth.

Brown University,
November 9, 1899.

THE ZOÖLOGY OF THE HORN EXPEDITION.

E. H. EATON.

A WORK of considerable importance, which has received too little attention in this country, is Professor Baldwin Spencer's *Report of the Horn Expedition to Central Australia*, published in September, 1896. The author's conclusions regarding the affinities of the Australian fauna are of vital importance, especially concerning the Antarctica theory, and a brief reference to the expedition, with a statement of its main results, may be of interest to readers of the *Naturalist*.

The object of the expedition was to explore the country about the McDonnell Ranges, which lie just south of the tropic between 129° and 135° east longitude. Leaving Adelaide in the beginning of May, 1894, the party proceeded by rail to Oodnatta, where the journey of 2000 miles by caravan was begun. There were five specialists in charge of the different departments, besides two collectors, a cook, and men to care for the camels. Mr. Horn, who equipped the expedition, accompanied it for a part of the journey in a carriage drawn by a team of camels.

The course lay for the most part through the dry country in the great Finke Basin, or Larapinta Land. Sandy deserts, "gibber" plains, dry river channels, with occasional water holes, scanty brush, and dried porcupine grass offered a monotonous scenery and poor prospects for collecting. By day the unclouded sun drove all but the hardiest creatures from the blistering sands; at night the temperature often fell many degrees below the freezing point. A yard away from the water holes the earth was parched and unfit for the habitation of animals or plants. In this region, however, during the rainy season, there is a wonderful change of scenery. Vegetation grows with amazing rapidity. Frogs, lizards, and mollusks creep from their hiding places, and their swarming descendants soon cover the country. Fishes and crustaceans are scattered by the swollen rivers from

the water holes where they have survived the dry season. Insects increase with the vegetation on which they feed, and the region is invaded by numerous birds which find their favorite food. Even rodents and marsupials immigrate sometimes in vast numbers from the surrounding regions.

But soon this brief season is past, and only the hardiest and those with special equipment to endure the ensuing drought and extremes of temperature survive the long dry season.

There was little opportunity for collecting specimens, except for an hour or two each day, when halting for food and water. If a rare lizard were seen hurrying away as the march was proceeding, before the unwilling camel could be compelled to fall back from its companion and kneel for dismounting, the agile lizard had made good its escape. Thus, only the twenty days of "spelling" in camp out of 125 days in the field were really available for taking specimens.

Besides several orders of invertebrates which had not been worked over when the report was published, there were 603 species of animals collected by the expedition, of which 171 species were new to science. The following is Professor Spencer's table of species collected:

MAMMALIA.	NO. OF GENERA.	NO. OF SPECIES.	NO. OF NEW SPECIES.
Carnivora	1	1	0
Chiroptera	2	2	0
Rodentia	3	11	3
Marsupialia	16	24	6
Monotremata	1	1	0
Aves	83	100	5
Reptilia	33	44	12
Amphibia	4	6	1
Pisces	5	8	5
Mollusca	20	38	21
Arthropoda	229	357	117
Vermes	1	1	1
	398	593	171

Several interesting observations on the fauna and flora of the center may be noted. The characteristic plants have their sur-

face adapted to prevent the evaporation of moisture, and their seeds can survive a long exposure, but germinate very rapidly as soon as the moist season arrives. The animals are such as can travel long distances with ease, like the dingo and the kangaroo, or can subsist on the dews of early morning. Some, like the burrowing frogs and mollusks, hide away from the withering sun, and others produce eggs which will not develop until after the mud in which they have been deposited dries up.

Professor Spencer thinks there is little attempt at protective coloration, in the struggle for existence, except in a general way. Nature seems to devote all her energies to the production of eggs which will develop precociously. The young, especially of insects, seem impelled to feed ravenously, and reach maturity before the favorable season is past.

As a result of the variable seasons, many species show a considerable discrepancy in size, individuals reared in successive good seasons being unusually large, while those growing in a succession of poor seasons are small. In one species, *Phascologale cristicauda*, the length of the head and body of the smallest adult male was 136 mm.; of the largest, 220 mm. The relationship of the fauna of the center to that of the surrounding regions is one of the strongest points in determining the probable source of Australian marsupials. The author divides the twenty-four species of the center into three main groups:

1. Those of continental distribution: *Trichosurus vulpecula*, *Sminthopsis murina*, *S. crassicaudata*, *Perameles obesula*.

2. A larger number, characteristic of the inland portion of eastern Australia, and of the south and west: *Macropus robustus*, *M. rufus*, *Petrogale lateralis*, *Onychogale lunata*, *Lagorchestes conspicilatus*, var. *leichardtii*, *Bettongia lesueuri*, *Chæropus castanotis*, *Phascologale calura*, *P. cristicauda*, *Dasyurus geoffroyii*, *Antechonomys laniger*, *Myrmecobius fasciatus*.

3. Those which as far as now known are peculiar to the central region: *Peragale minor*, *P. leucura* (probably), *Perameles eremiana*, *Sminthopsis psammophilus*, *S. larapinta*, *Phascologale macdonnallensis*, *Dasyuroides byrnei*, *Notoryctes typhlops*.

Professor Spencer calls attention to the fact that there is no indication of primitive monotremes of marsupials characteristic

of western Australia, and that the monotremes and polyprotodonts diminish in importance as we pass northward and northwestward from southeastern Australia.

The birds collected range over the southern portion of the continent from east to west, with a slight preponderance of western forms. The reptiles show a marked affinity with the west and north. The Amphibia, with the exception of *Hyla rubella,* are allied to those of the southeastern portion. The fishes are related to those of the coastal districts, and not to those of the Murray River system; they probably were derived from the north. The mollusks are related to the west, and, in a slight degree, to the eastern interior. The other invertebrates in the center are too imperfectly known to furnish reliable generalizations.

As a result of his investigations, Professor Spencer draws some highly interesting conclusions in respect to the faunal affinities of the island continent and the geologic changes that have combined to establish this remarkable life here. These views, while they differ in some marked particulars from those of Darwin, Wallace, and Lydekker, are, we believe, in line with the very latest scientific developments. They may be stated briefly as follows:

1. Probably a very ancient connection with southeastern Asia, existing partly in the western and partly in the eastern portions of the island, when these were separate land masses, furnished the original inhabitants, which are represented to-day, perhaps, by such forms as Xanthomelon, Peripatus, Ceratodus, Amphibolurus, Moloch, and the families Pygopodidæ, Meliphagidæ, and Trichoglossidæ.

2. A great marine area, in which the Upper Cretaceous rocks of the Rolling Downs were deposited, completely separated the western and eastern portions and isolated the higher Steppes from the ancient region further west.

3. Across the Torres Straits a connection in late Cretaceous times with a Papuan area, and with Polynesia and the New Zealand region, accounts for the distribution of Microphyura, Acanthodrilus, and the struthious birds of Australia and New Zealand; also for the introduction of the Paradiseidæ, Megapo-

didæ, Rana, Heteronota, Physignathus, Perichæta, and from the Austro-Malayan area, and later, for the passage northward of monotremes and marsupials. The union with New Zealand was severed, and only that with New Guinea probably remained at the time when the Prototheria and Metatheria had become established on the Australian continent.

4. Perhaps in later Cretaceous times, and certainly not later than the Miocene, a union with South America by way of Tasmania and Antarctica resulted in the introduction of such forms as Gundlachia, Geotria, Galaxias, Haplochiton, Aphritis, and the Cystignathidæ, Marsupialia, and possibly the Monotremata.

5. The union of eastern and western Australia, and the formation during the Tertiary period of a great lacustrian area and of pluvial conditions in the interior, favored the development of the gigantic diprotodont and struthious forms of the Pliocene period.

6. The elevation of the coastal range barrier, which was much higher in Tertiary times than at present, prevented the free intermingling of the coastal forms with those of the inland regions.

7. The isolation of the Australian continent, by the obliteration of the land connections referred to, has preserved to a great extent its unique animal life. The union with Tasmania was doubtless severed prior to the Pliocene times, when the dingo and large diprotodonts existed in Australia.

8. The desiccation of the interior in Post-Pliocene times partly replaced and partly intensified the mountainous barrier near the coast, and combined with this to separate the desert fauna from that of the well-watered districts.

After careful study of the animals collected by the Horn Expedition, and comparison with specimens from the remainder of the continent, Professor Spencer concludes that western Australia has no claim to the title "Autochthonian," as far as the higher forms at least are concerned. He discards this term, which was introduced by Professor Tate with reference to the flora. The Euronotian region of the same author he finds made up of two well-defined areas, each of which is marked by characteristic animal forms, and prefers to divide the Australian region as follows :

1. The Torresian subregion. This is the Papuan subregion of Professor Hedley, but Professor Spencer prefers the name Torresian, as less liable to lead to confusion, and as indicating the former land connection. It includes Papua and north and northeastern Australia as far south as the Clarence River.

2. The Bassian subregion, which comprises the eastern and southeastern coast region, and Tasmania. The name indicated the route by which "the South American contingent must have passed."

3. The Eyrian subregion, including all the interior, southern, and western part of the continent. It is separated by the coastal ranges from the Torresian region on the northeast, and from the Bassian region on the southeast.

The theory of a former connection between Australia and South America by means of a great southern continental area now seems thoroughly established. Mr. Wallace thought the relationship between the marsupials of the two countries, and between several families of birds and reptiles, too general to be accepted as direct evidence. He admitted, however, that cystignathous frogs, several genera of fresh-water fishes, and one genus of snail were undoubtedly transported from one region to the other, but thinks this transportation was by means of floating ice. Mr. Lydekker, in his *Geographical History of Mammals* (1896), still maintained that the evidence was too scanty to show in what latitude the connection occurred. He admits that the discovery of dasyuroid marsupials in the Tertiary of Patagonia indicates a former communication, and he points out the importance of the determination of the rocks recently brought back by the *Antarctic* as indicating a continental area; but he thinks the presence of Australian types of rats in the Philippines "is of the utmost importance in respect to Australia receiving its mammalian fauna from southeastern Asia"; and he believes that this fauna entered the island by way of New Guinea.

Professor Spencer calls attention to the fact that polyprotodont forms decrease in importance toward the north and northeast in Australia (which is the opposite of what should be the case if Professor Lydekker's theory is the true one), and pointedly remarks that Australian rats in the Philippines do not prove

that the marsupials came from the north, any more than it proves that the fish Galaxias is an immigrant from Asia. At the same time Mr. Lydekker admits that the rats are comparatively recent immigrants, and that because of their small size they may have been introduced without direct land connection.

After reading Professor Spencer's summary of evidence, and examining an atlas of the southern circumpolar regions, one is forced to admit the extreme probability of this ancient connection of southern lands, including South America, Australia, and New Zealand. We may also add Africa, in the light of Mr. Spencer Moore's paper on the origin of the Australian flora, published in *Natural Science*, September and October, 1899.

Mr. Moore speaks of this land connection practically as an axiom of science. Dr. Moreno's publication in *Nature*, Aug. 4, 1899, of the discovery of Miolania in the Tertiary of Patagonia, also of diprotodon and other marsupials in the same deposits, adds evidence on the subject which is well-nigh conclusive.

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A GLACIAL POT-HOLE IN THE HUDSON RIVER SHALES NEAR CATSKILL, N. Y.

HENRY FAIRFIELD OSBORN.

Some years ago I was invited to examine a pot-hole of unusual interest, which had recently been uncovered on the east bank of the Hudson, directly opposite the town of Catskill, upon the estate of Frederick E. Church, the well-known landscape artist. At the time a number of drawings and photographs were taken, together with a few notes which may be of interest to the readers of the *Naturalist*.

This pot-hole lies at the base of a cliff of shale about seventy-five feet high, and was discovered in course of excavation of

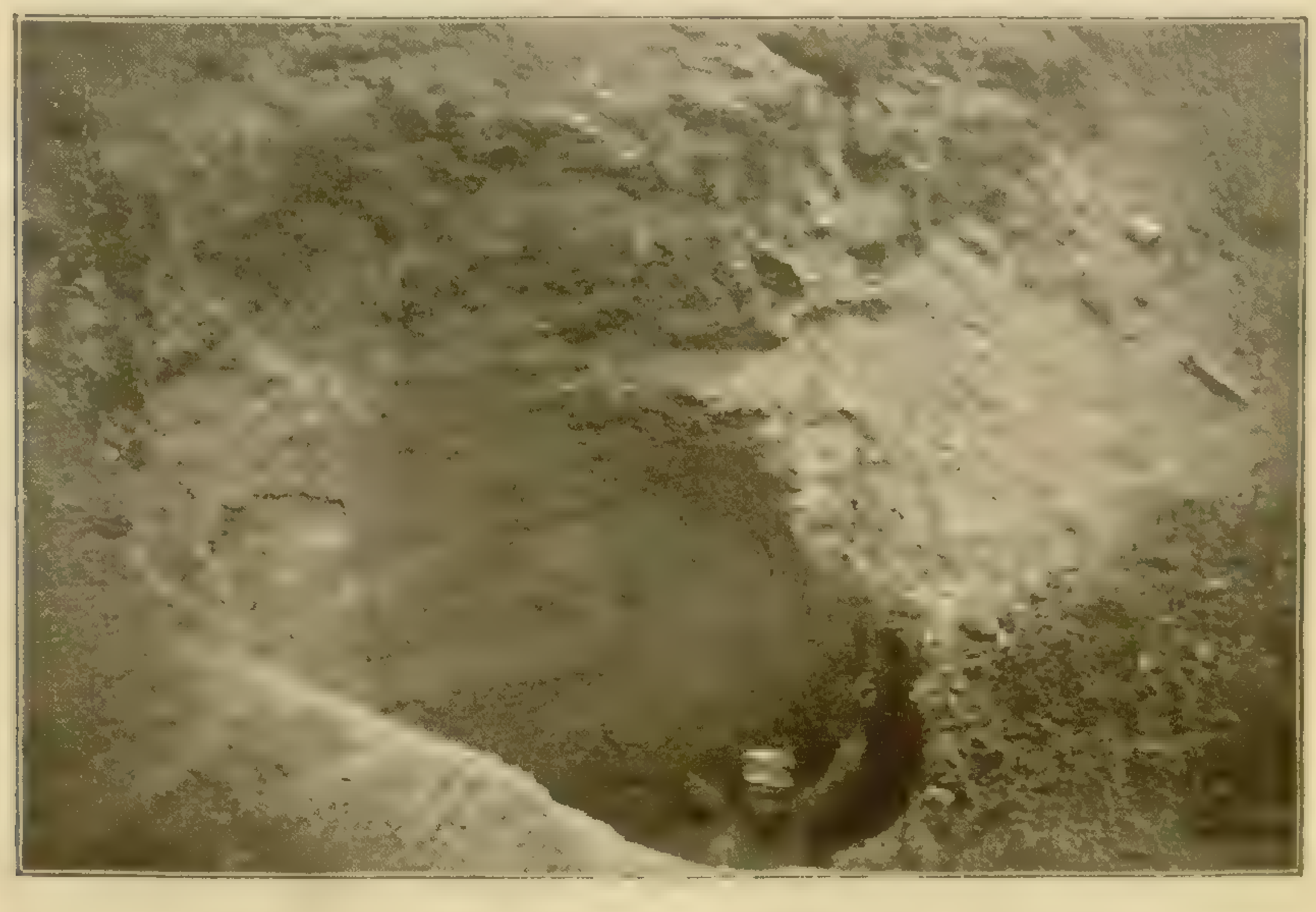

Fig. 1. — Side view of shale cliff and pot-hole.

the shale for purposes of road-building. It was first indicated by a section of its diameter upon the side nearest to the base of the sharp cliff. It was then excavated with great care to a depth of twenty-five feet, when it suddenly narrowed from an average diameter of eight feet to a diameter of five feet, and finally it was found to terminate in a bowl about the size of a wash-basin.

The whole section for a distance of twenty feet in the comparatively soft shale exhibits the sides worn very smooth, almost to a polish. At the point of contraction the pot-hole dips into a stratum of black slate which is quite highly polished. The shale belongs to the Hudson River Series, and the slate to the Utica Slate.

The upper portion of the pot-hole was filled with shale débris which had evidently fallen from the cliff. This was followed by

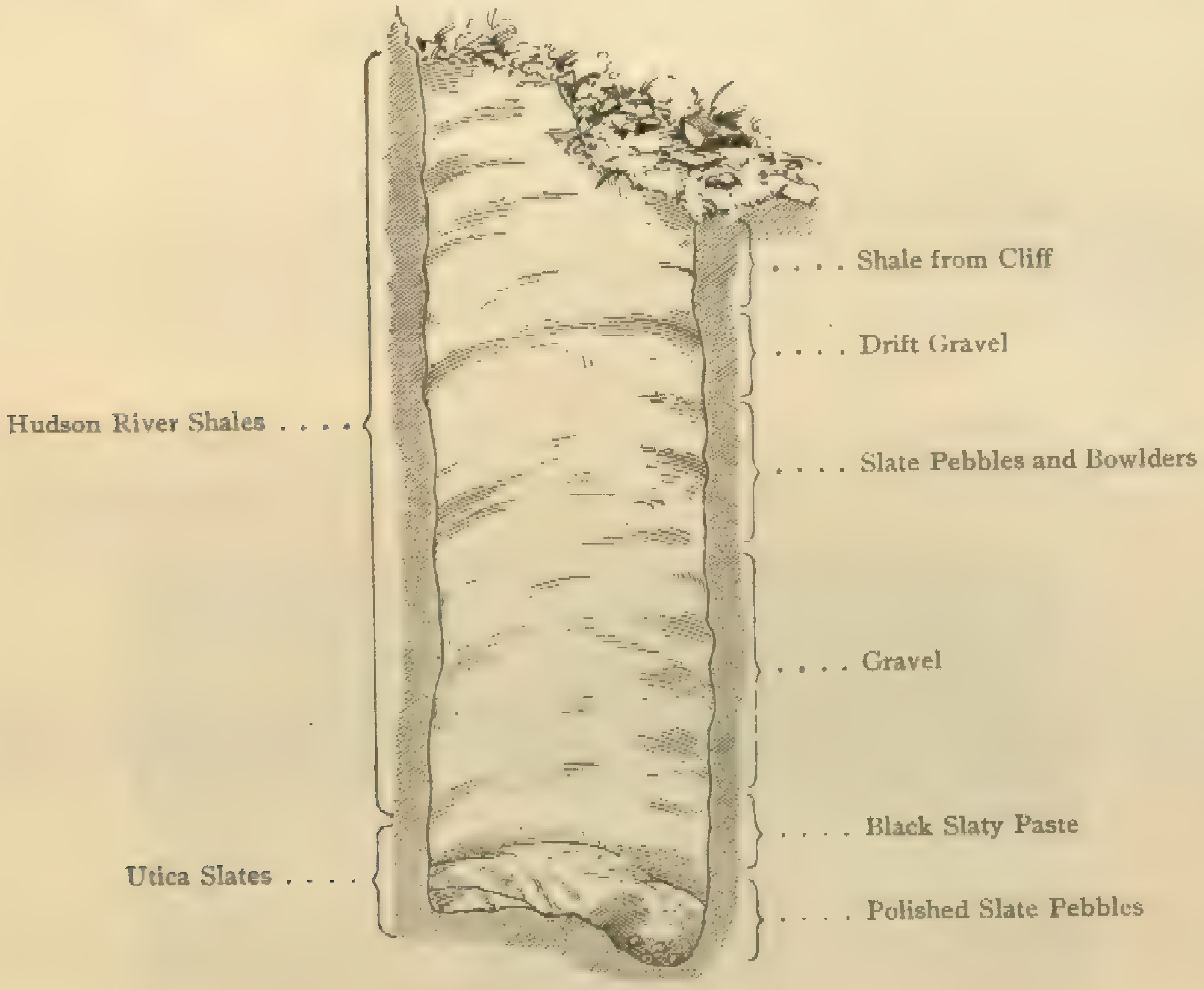

FIG. 2.

a stratum of five feet of gravel, similar to ordinary drift gravel, containing pebbles and well-rounded bowlders, varying from one inch to two feet in diameter. This was followed by a thick stratum of slate pebbles, while the lower portion of the bowl was filled with the black paste left from the wearing of the slate and containing a few perfectly rounded pebbles. There were no crevices to account for the carrying off of the stream of water which must have produced this pot-hole, and its depth indicates that it was formed in the bed of a powerful stream.

At the top of the pot-hole the face of the cliff ascends sharply,

and the surrounding sides have been uncovered so recently that we have every reason to believe the pot-hole was originally of very much greater depth than at present; and this, together with its peculiar position, renders it rather difficult to explain its origin and history. Its location is about half a mile back from the river, and the face of the cliff has a north and south direction.

In the twenty-first annual report of the Regents of the University of the State of New York on the condition of the State Cabinet of Natural History, published in Albany in 1871, is

Fig. 3. — Pot-hole viewed from above, showing top of Utica slate layer where the erosion began to diminish.

found an account of the discovery of the Cohoes Mastodon by Professor James Hall. He here gives an interesting description of the glacial pot-holes in the vicinity of the present gorge of the Mohawk near Cohoes. These holes are now mostly covered by swamps and were evidently bored out from the general level. They reached a depth of from seventy to eighty feet, and their cross-sections varied from eight to thirty-five feet.

From these facts it appears probable that the Catskill pot-hole here described originally extended to the level of the top of the cliff.

Its formation was in this case similar to that which has been observed as now in process beneath some of the glaciers of Switzerland, Norway, and Sweden. In Norway they exist in

great numbers and are popularly known as "Giants' Kettles." In Oswald Heer's *Urwelt der Schweiz* we find a full description of some of the Swiss pot-holes. On the mode of formation of these holes Geikie speaks as follows: "Among the Alps, during the day in summer, much ice is melted and the water courses from the glaciers accumulate in brooks which, as they reach the crevasses, tumble down in rushing waterfalls, and are lost in the depths of the ice. Directed, however, by the form of the ice passage against the rocky floor of the valley, the water descends at a particular spot, carrying with it the sand, mud, and stones which it may have swept away from the surface of the glacier. By means of these materials it erodes deep pot-holes in the solid rock, in which the rounded detritus is left as the crevasse closes up or moves down the valley."

THE VISITORS OF THE CAPRIFOLIACEÆ.

JOHN H. LOVELL.

THE Caprifoliaceæ, or honeysuckle family, are remarkable for the variation in length of the corolla tube and the consequent adaptation of the flowers to a great variety of visitors. The wheel-shaped flowers of Sambucus contain no honey and are sparingly visited by flies and pollen-collecting bees; Viburnum, which has also a rotate corolla but secretes nectar, attracts a wide circle of bees, flies, beetles, and Lepidoptera; the corolla of Symphoricarpos is bell-shaped and visited chiefly by wasps; the funnel-formed flower of Linnæa is adapted to slender flies; *Lonicera alpigena* is a wasp flower; a part of the species of Lonicera are visited by bees in general, while others are pollinated only by bumblebees; *L. caprifolium* and *L. periclymenum* are nocturnal flowers fertilized by hawk moths; and *L. sempervirens* is pollinated by humming birds.

There are about 260 species widely distributed throughout the northern hemisphere and blooming in spring and midsummer. A few occur in South America and Australia. Their northern distribution, as well as the occurrence of fossil forms, indicates their origin in the north temperate zone. Viburnum is found in the Dakota group, which, according to Saporta and Marion, belonged to a woody and mountainous region, populated by such genera as Salix, Fagus, Populus, and Platanus, and from which southern types, especially the palms, are absent.

SAMBUCUS L.

The flowers attract very few visitors, as they contain no nectar.

Sambucus pubens Michx. Red-berried Elder.

The flower buds are at first green, changing to purplish, and finally, on expanding, to white. Cymes thyrsoid, longer than broad.

Visitors: Hymenoptera — Apidæ: (1) *Apis mellifica* L., ♀; Andrenidæ: (2) *Andrena vicina* Sm., ♀.

Diptera — Syrphidæ: (3) *Syrphus ribesii* L.

Coleoptera — Cerambycidæ: (4) *Pachyta monticola* Rand; Mordellidæ: (5) *Anaspis rufa* Say. Waldoboro, May 19 to June.

Sambucus canadensis L. American Elder.

The broad, flat cymes are very numerous and conspicuous. The flowers attract very few visitors, as they contain no honey and bloom at midsummer, when they come in competition with many nectariferous blossoms. Only four species of flies have been collected, and repeatedly the blossoms were examined without observing a single visitor, and yet upon the jewel-weed (Impatiens) and the red-osier cornel, a few yards away, scores were at work. The perfume is agreeable and increases in the evening, but fails to attract crepuscular insects. The stamens are slender, surpassing the nearly sessile stigmas.

Visitors: Diptera — Syrphidæ: (1) *Mesogramma marginata* Say; Sarcophagidæ: (2) *Helocobia helicis* Town.; Muscidæ: (3) *Lucilia cornicina* Fab.; Anthomyidæ: (4) *Phorbia fuscipes* Zett. Waldoboro, July.

Sambucus nigra L. Black Elder.

A variety of this species, *S. nigra laciniata* (Mill.) DC., has escaped from cultivation at Cape May, N. J. According to Knuth, the flowers of *S. nigra* are yellowish-white, honeyless, and conspicuousness is gained by their aggregation in a dense corymb. There are few visitors, partly because the strong scent is probably repellent to bees, and partly because of the absence of nectar. In the Island of Föhr, Knuth collected two flies feeding upon the pollen, and in Helgoland a single fly, *Lucilia cæsar.* In middle and southern Germany, Müller observed six flies, two beetles, and one sawfly.

Viburnum L.

There are fourteen species in the Northern States. The flowers are in compound cymes, which bloom in early spring or midsummer, and are white, fragrant, and nectariferous.

Viburnum alnifolium Marsh. Hobble Bush.

The inflorescence is in broad, flat corymbs of flowers of two different sizes. The center florets are small, 5 mm. broad, white tinged with red, and in autumn produce bright-red berries; while the marginal ones, a single row of which surrounds the corymb, are large, 20 mm. broad, white, and sterile. Their size has been increased at the expense of their fruitfulness, and as their use is to attract the attention of insects, they open a day or two in advance of the inner and smaller florets. "The older flowers are actually occupied," Kerner remarks, "in the allurement of insects for the advantage of the younger ones." Since their conspicuousness is useless to themselves but of benefit to the community, they may be said unconsciously to play the part of benefactors. The stamens stand nearly erect, and spontaneous self-fertilization can easily occur by the pollen falling upon the sessile stigmas.

Visitors: Hymenoptera — Apidæ: (1) *Apis mellifica* L., ☿; (2) *Bombus bifarius* Cr., ♀; (3) *Nomada maculata* Cr., ♀; Andrenidæ: (4) *Andrena sp.;* (5) *A. sp.*

Diptera — Syrphidæ: (6) *Syrphus ribesii* L.; (7) *Brachypalpus marginatus* Hunter; Muscidæ: (8) *Myiospila meditabunda* F.; Cordyluridæ: (9) *Scatophaga stercoraria* L.

Coleoptera — Elateridæ: (10) *Elater rubricus* Say; (11) *Megapenthes rogersii* Horn[1]; Cerambycidæ: (12) *Cyrtophorus verrucosus* Oliv.; (13) *Microclytus gazellula* Hald.; Œdermeridæ: (14) *Asclera ruficollis* Say; Mordellidæ: (15) *Anaspis rufa* Say; also *Pachyta monticola* Rand.

Hemiptera — two species. Waldoboro, May 9–19.

Viburnum lentago L. Sweet Viburnum.

The flowers are homogamous. The stamens are much longer than the stigmas and divergent; self-fertilization is not, how-

[1] In his list of Coleoptera from the southern shore of Lake Superior, 1896, Prof. H. F. Wickham remarks: "Of the Elateridæ it is a pleasure to record the capture of a fine specimen of *Megapenthes rogersii*, a rare insect recorded hitherto only from Canada." The specimen taken by the writer was determined by Professor Wickham.

ever, impossible, as the inflorescence often stands in such a position that the stigma is directly in line with the falling pollen. The large size of the cymes and their great abundance render the bush very conspicuous. The odor is faint but agreeable. Honey is secreted in a thin adherent layer by the ovary, but may be observed more readily in the angle formed with the corolla, where it is sought by insects.

Visitors: Hymenoptera — Apidæ: (1) *Apis mellifica* L., ☿, common; Andrenidæ: (2) *Halictus disparalis* Cr., ♀; (3) *Andrena vicina* Sm., ♀, common; (4) *A. rugosa* Rob., ♀; (5) *A. designata* Ashm., ♀; (6) *A. violæ* Rob., ♀; (7) *A. claytoniæ* Rob., ♀.

Diptera — Syrphidæ: (8) *Eristalis transversus* Wied.; (9) *E. saxorum* Wied.; (10) *Syrphus ribesii* L.; (11) *Sphærophoria cylindrica* Say; (12) *Mellota postica* Fab.; (13) *Helophilus latifrons* Loew; (14) *Syritta pipiens* L.; Empididæ: (15) *Rhamphomyia luteiventris* Loew; Muscidæ: (16) *Morellia micans* Macq.; also minute Diptera.

Coleoptera — Nitidulidæ: (17) *Carpophilus brachypterus* Say; (18) *Colastus truncatus* Rand; Cerambycidæ: (19) *Leptura lineola* Say; Scarabæidæ: (20) *Hoplia trifasciata* Say; Mordellidæ: (21) *Anaspis rufa* Say. Waldoboro, June 16, 17, 18, and 21.

Viburnum dentatum L. Arrowwood.

Honey is secreted by the lower part of the ovary, and there is a faint, rather peculiar fragrance. The stamens are 5 mm. in length and much surpass the stigmas. The flowers are not so frequently visited by insects as *V. lentago*. In addition to the list given below, two butterflies were seen at a distance upon the inflorescence.

Visitors: Hymenoptera — Andrenidæ: (1) *Halictus sp.*; (2) *Andrena rugosa* Rob., ♀.

Diptera — Syrphidæ: (3) *Syrphus ribesii* L.; (4) *Chilosia sp.*

Coleoptera — Elateridæ: (5) *Elater rubricus* Say; (6) *Sericosomus incongruus* Lec.; Cerambycidæ: (7) *Leptura chrysocoma* Kirby; (8) *L. vittata* Germ.; (9) *L. lineola* Say; Scara-

bæidæ: (10) *Hoplia trifasciata* Say; (11) *Macrodactylus subspinosus* Fab.

Hemiptera — one species. Waldoboro, July 6–10.

Viburnum cassinoides L. Withe Rod.

The structure of the flowers is very similar to that of the preceding species. The perfume is distinct, and the flowers contain honey.

Visitors: Hymenoptera — Andrenidæ: (1) *Andrena vicina* Sm., ♀; (2) *Halictus palustris* Rob., ♀.

Lepidoptera — Rhopalocera: (3) *Lycæna pseudargiolus* Boisd. & Lec.

Diptera — Syrphidæ: (4) *Sphærophoria cylindrica* Say; (5) *Syrphus ribesii* L.; Empididæ: (6) *Empis pubescens* Loew; (7) *Rhamphomyia luteiventris* Loew; Sapromyzidæ: (8) *Sapromyza longipennis* Fab.

Coleoptera — Elateridæ: (9) *Agriotes stabilis* Lec.; (10) *A. fucosus* Lec.; Lampyridæ: (11) *Telephorus fraxini* Say; Cerambycidæ: (12) *Leptura mutabilis* Newm.; (13) *Pachyta monticola* Rand; (14) *Molorchus bimaculatus* Say; Cistellidæ: (15) *Isomira quadristriata* Coup. Waldoboro, June 26–28.

In *V. pubescens* Pursh and *V. prunifolium* L. the flowers are homogamous, and spontaneous self-fertilization and geitonogamy may occur. (Robertson, *Bot. Gaz.*, Vol. XXV, No. 4.)

	Apidæ.	Andrenidæ.	Other Hymenoptera.	Syrphidæ.	Empididæ.	Other Diptera.	Coleoptera.	Lepidoptera.	Total.	Date.
V. prunifolium, Illinois, Rob. .	9	26	2	17	2	13		7	76	April 24–29
V. pubescens, Illinois, Rob. . . .	6	21		7	13	7	18	2	73	May 4–9
V. opulus, Germany, Müller . . .		1		6	1	1	7		16	
V. alnifolium, Maine	3	2		2		2	6		15	May 9–19
V. lentago, Maine	1	6		7	1	1	5	1	22	June 16–21
V. cassinoides, Maine		2		2	2	1	7	1	15	June 26–28
V. dentatum, Maine		2		2			7		11	July 6–10

An examination of the table shows that the most important visitors are Andrenidæ, flies, and beetles, to which the inflo-

rescence, with its freely exposed honey, is well adapted. The long-tongued bees are comparatively rare. The smaller bees are very efficient pollinators, and the species are both numerous and common. The absence, as a rule, of other Hymenoptera is noteworthy. Of Diptera the Syrphidæ and Empididæ are the most important. The latter are most abundant in May, the time of blooming of several species of Viburnum. Many minute flies also seek the flowers. Beetles are very frequent visitors to all the species except *V. prunifolium*, to which none are recorded. This is certainly remarkable, and further observations are desirable. Delpino included *V. opulus* among the flowers adapted to beetles, but Müller regarded flies as the most efficient pollinators. The variety of Coleoptera is interesting, as the twenty-six visits I have enumerated were made by twenty-one species. Lepidoptera are rare, as the long proboscis of these insects is not adapted to suck the honey in rotate flowers.

Symphoricarpos Juss.

There are a few flowers which are adapted to wasps, and to which these insects are very frequent visitors. The most important wasp flowers are *Epipactis latifolia* Swartz, *Cotoneaster vulgaris* Lindl., *Scrophularia nodosa* L., *Symphoricarpos racemosus* Michx., and *Lonicera alpigena* L., the last two belonging to the Caprifoliaceæ. The flowers agree in having abundant honey secreted in a short corolla, or pouch-like receptacle, about the size of a wasp's head, and usually lurid colors. In England *Epipactis latifolia* is visited by swarms of wasps, which effectually fertilize the plants, and although Darwin saw hive bees and bumblebees of many kinds constantly flying over the plants, he never saw a bee or any dipterous insect visit the flowers. He expresses astonishment that the sweet nectar should not be attractive to any kind of bee.[1] Müller's statement is very clear. He says: "This plant in the Alps often grows on the same rocks to which a wasp (*Polistes gallica*) has attached its stalked, open nests. I have found the flowers visited solely by the above-mentioned wasp, whose head just

[1] Darwin, *On the Fertilization of Orchids by Insects*, p. 102.

fits into the flower."[1] The same observer found in Westphalia five species of wasps very common visitors to *Scrophularia nodosa.* This flower exhibits retrogressive modification in that the upper fifth stamen, which is useless, is reduced to a sterile black scale.

Symphoricarpos racemosus Michx. Snow Berry.

The small reddish flowers are campanulate and pendulous. The ample supply of honey, secreted by the base of the corolla, is prevented from escaping by numerous slender hairs which line its anterior portion. The short pistil is only about half the length of the corolla, to the sides of which are attached the stamens, with the anthers converging toward the center. The flowers are homogamous. "As the wasp thrusts its head wholly into the flower, it comes at once in contact with all five anthers and then touches with one side the stigma; but on its way to the stigma little or no pollen remains attached to it, partly because the pollen is very slightly adhesive, and partly because any grains that do attach themselves are brushed off before they reach the stigma by the hairs lining the corolla."[2] But after the insect's head has been moistened with honey it acquires a plentiful coating of pollen, which is carried to the next flower.

In Thuringia, according to Müller, nine-tenths of all the visitors belong to five species of wasps; while at Lippstadt, where wasps are much less abundant, the honey bee preponderates. At Rendsburg, Schröder observed that the flowers were visited by numerous Noctuidæ between the hours of 9 and 10 in the evening; in Belgium, Macleod collected nine species of night-flying moths belonging to this family. The more important observations are given in the table[3] on the following page.

[1] Müller, *Alpenblumen*, p. 214.

[2] Müller, *Fertilization of Flowers*, p. 292.

[3] Knuth, *Handbuch der Blütenbiologie*, Bd. ii, Nr. 1, p. 527.

	Wasps.	Apidæ.	Andrenidæ.	Other Hymenop.	Diptera.	Total.
Southern Germany, Müller	7	6	2	1	1	17
Heringsdorf, Knuth	3	2				5
Brandenburg, Loew	4	2			6	12
Bremen, Alfken	2	11				13
Paris, Bonnier	3	2	1			6

Symphoricarpos symphoricarpos (*L.*) *MacM.*; *S. vulgaris Michx.* *Coral Berry.*

The greenish-white flowers tinged with rose have essentially the same structure as those of the preceding species. The stigma and anthers also mature together. In Illinois, Robertson collected, between July 8 and August 30, the following visitors: Wasps, 5; Andrenidæ, 5; Sphecidæ, 1; Pompilidæ, 1.[1]

LINNÆA L.

A monotypic genus.

Linnæa borealis L. Twin Flower.

One of the most attractive of June flowers is the twin flower, *Linnæa borealis* L., named after Linnæus, with whom it was a special favorite. It extends throughout the eastern Northern States, from Newfoundland and through British America, Alaska, Siberia, and northern Europe to England. It is a trailing evergreen vine densely carpeting the ground in cold, open woodlands. The nodding pinkish blossoms are borne in pairs at the summit of elongated peduncles, and exhale a sweet, vanilla-like fragrance. The funnel-formed corolla is five-lobed, nearly regular, though the two superior lobes are slightly larger. The tube is 8 mm. in length, and for 3 mm. is very small. The inverted position of the flower excludes rain. The lobes are whitish, the tube wine-colored, with a yellow marking on the lower side which serves as a honey guide. The honey is secreted on the same side, at the base of the corolla, between

[1] *Trans. Acad. Sci. of St. Louis*, vol. vii, No. 6, April, 1896.

the two shorter stamens. The stamens are four, included, didynamous, and the anthers dehisce introrsely. The total length of the flower is about 10 mm., of the pistil 11 mm., so that the green capitate stigma is exserted, an arrangement favoring cross-fertilization. A legitimate visitor, in creeping over the edge of the bell, comes in contact first with the stigma and deposits upon it pollen brought from another flower; subsequently, while sucking honey, the underside of its body brushes the anthers of the two longer stamens, and the head touches the anthers of the two shorter. Within the corolla are many inter-crossing hairs, which exclude small, useless flies, which I have seen vainly seeking an entrance. They also afford a foothold to the proper guests.

During a part of an afternoon a large bed of Linnæa in full bloom was carefully observed, and eight visitors were collected. On examination they all were found to belong to a single species of fly, *Empis rufescens* Loew, of the Empididæ. Other observations showed that in this locality this fly is the most frequent and perhaps the only pollenizer. In the Alps, Müller observed three Diptera and one butterfly. The butterfly was probably an accidental visitor, as these insects are unusually abundant in the Alps. Loew saw in Brandenburg a long-legged fly, *Neurigona quadrifasciata* F., of the family Dolichopodidæ. This family is closely allied to the Empididæ. The flowers of *L. borealis* L. are, then, in both continents, adapted to slender flies which live in woodlands. I saw a female bumblebee fly over a bed of the flowers without paying any attention to them. Self-fertilization may occur by the pollen falling in some instances upon the stigma.

Visitors: Diptera; Empididæ; *Empis rufescens* Loew, sucking, common. Waldoboro, June to July 6.

Lonicera.

Lonicera ciliata Muhl. American Fly Honeysuckle.

This is the only species of Lonicera native in this locality. The pendulous, funnel-formed flowers are sheltered beneath the young leaves. The tube is 10 mm. to 11 mm. long and con-

tains nectar in a spur near the base. Female species of Bombus, in their haste to obtain the nectar, frequently puncture the tube a short distance above the spur. The flowers are slightly proterogynous. The stigma usually stands a few millimeters in advance of the anthers, but in several instances I have seen it resting directly against them, so that self-fertilization may occur. The color is greenish-yellow. The flowers are visited by *Bombus vagans* Sm., ♀, and several small bees. The blooming season is from May 7 to 15.

The genus Lonicera includes about 100 species, chiefly natives of the north temperate zone. According to the visitors which pollenize the flowers, they may be divided into wasp flowers, bee flowers, bumblebee flowers, hawk-moth flowers, and bird flowers.

1. *Wasp Flowers.* — In the Alps, *L. alpigena* L. is adapted to wasps. The tube is short, with a prominent pouch-like receptacle which contains abundant honey; the entrance is protected by stiff hairs. The lower lip affords a convenient landing place. An insect comes in contact first with the stigma and subsequently with the anthers. Müller states that the flowers are homogamous, but according to Kerner they are proterogynous. The color is reddish-brown. Müller observed in the Alps 2 species of wasps in great numbers; Bombus, 3; other bees, 4; Syrphidæ, 2; Lepidoptera, 2; Coleoptera, 2.

2. *Melittophilous, or Bee Flowers.* — *L. tartarica* L. and *L. nigra* L. are visited by both the larger and smaller bees. The stigma and anthers in both species ripen simultaneously and are in close proximity; bees push their way into the flower between them and come in contact with both. Self-fertilization may occur by the insect thrusting the anthers against the stigma. *L. tartarica* is pink or white, with a tube 6 mm. long, and in Germany is visited by: Apidæ, 2; Andrenidæ, 1; Syrphidæ, 1 (Müller). Upon *L. nigra*, Apis, Bombus, and numerous smaller bees and flies have been observed.

3. *Bombus Flowers.* — The length of the tube in the bumblebee flowers varies from 3 to 15 mm., while the proboscis of the largest bees is 21 mm. long. The stamens diverge so widely that the smaller bees and flies may never touch the stigma.

Self-fertilization may occur. The color is pale yellow, or yellow.

	Length of Tube in Millimeters.	Bombus.	Other Hymenoptera.	Lepidoptera.	Diptera.	Total.
L. xylosteum, Westphalia, Müller	3–4	2	1		2	5
L. cærulea, Alps, Müller . . .	6–7	6	11	3	2	22
L. sullivantii, Illinois, Robertson	14–18	2	1		1	4

4. *Sphingophilous, or Hawk-moth Flowers.* — *L. caprifolium* L. and *L. periclymenum* L. are adapted to crepuscular and nocturnal Lepidoptera, especially to the hawk moths; while bees are only accidental visitors. The flowers are two-lipped and, when in bloom, stand nearly horizontal. The anthers turn their pollen-covered sides upward, and the whole underside of the moth is covered with pollen. The stigma protrudes so far in advance of the anthers that self-fertilization is not likely to occur. The honey is abundant and is secreted in the lowest part of the corolla tube, while in the non-twining honeysuckles the corolla possesses a honey-forming expansion above the base.[1] The flowers expand in the evening, when they exhale their fragrance most strongly.

L. caprifolium has a tube 30 mm. long and 1 or 2 mm. wide. The color is purplish without and white within. Müller collected upon the flowers in Westphalia: Sphingidæ, 6; other Lepidoptera, 4. The proboscis of the large hawk moth, *Sphinx convolvuli*, is 65 to 80 mm. in length. The fragrance of the honeysuckle is perceived by this moth at a long distance. Kerner removed one of these moths to a part of the garden 300 yards away from the honeysuckle and marked it with cinnabar. "When twilight fell, the hawk moth began to wave the feelers which serve it as olfactory organs hither and thither a few times, then stretched its wings and flew like an arrow through the garden to the honeysuckle." The same observer states that butterflies pass over the flowers without pausing,

[1] Kerner, *The Natural History of Plants*, vol. ii, pp. 177, 178.

and that the fragrance is either unperceived or is unpleasant to them.

The tube of *L. periclymenum* is 22 to 25 mm. long, so that the honey, which may fill the tube for half its length, is also accessible to bumblebees. During the first evening the interior of the flowers is white, and the matured anthers stand directly in front of the entrance, while the stigma is bent abruptly downward. On the second evening the color within has changed to yellow, the stigma has moved upward and stands in front of the flower, while the anthers are in turn bent downward. It is doubtless designed that moths should visit the flowers in the first stage before those in the second. Knuth was, however, unable to determine in the evening which kind of flowers was sought first, as the moths move with great rapidity. In this connection the color change is probably of not much significance. The hawk-moth flowers were once bumblebee flowers, with yellowish coloration. After the hawk moths had dispossessed the bees, the production of yellow pigment was no longer beneficial, and consequently tended to disappear. Its reappearance in the older flowers is due partly to reversion and partly to oxidation, for the flowers in wilting continue to darken and turn a dingy orange-brown. Moreover, yellow is probably as conspicuous as white in the evening, and nocturnal flowers, as the evening primrose, (*Œnothera biennis*, may be yellow-colored.

On the Island of Föhr, Knuth collected: Sphingidæ, 5; Noctuidæ, 1; Diptera, 4; Bombus, 1. The same observer saw in Helgoland: Sphingidæ, 2; Noctuidæ, 2. Heinsius saw in Holland: Bombus, 1, as well as many pollen-eating flies. Macleod observed in Belgium: Bombus, 2; Sphingidæ, 1.

5. *Ornithophilous or Bird Flowers.* — *L. sempervirens* L. is fertilized by the ruby-throated humming bird. The narrow tube is 25 to 35 mm. long, with a regular limb. The color is scarlet outside, yellow within, or rarely throughout. The flower is scentless. Crimson or scarlet is the characteristic color of bird flowers, as *Lobelia canadensis* and *Tecoma radicans*. Red appears to be the favorite color in bird æsthetics, and a larger number of edible fruits display this hue than any other. Of

the fourteen species of Lonicera in the Northern States, ten have red berries, one yellow, and three black, or bluish-black. The original color of *L. sempervirens* was undoubtedly yellow, to which it occasionally reverts. This color change is very common and may occur in the course of the development of the individual flower. In certain South American species of Lantana the flowers are at first yellow, when they are visited by bees, and later change to red, and are then attractive to butterflies. *L. sullivantii* is also visited by the humming bird.

Diervilla Mœnch.

This genus is confined to North America and consists of two species; one is distributed throughout the north temperate zone, the other is found in the mountains of the Southern States.

Diervilla diervilla (L.) *MacM.; D. trifida Mœnch.* *Bush Honeysuckle.*

The northern species, *D. diervilla*, is a low shrub growing in rocky woodlands and thickets. The flowers are solitary or in few-flowered cymes. The corolla is funnel-formed, more or less two-lipped, with a tube 7 mm. long, light yellow, the upper lobe marked with an orange honey guide. The honey, which is abundant and may fill the tube for 3 mm. of its length, is secreted by a thick quadrangular gland at the base of the tube on the upper side. The lower portion of the filaments, style, and middle lower petal are bearded, the hairs serving to exclude small insects and the wet. The odor is very faint or absent. The older flowers turn reddish, a color change which also occurs in *Ribes aureum* and in the genera Weigelia, Fuchsia, and Lantana. In *Ribes aureum*, Müller states that the more intelligent insects immediately recognize those flowers which no longer contain nectar, and consequently visit more blossoms in the same time.[1] Repeated observations failed to show that the color change in *D. diervilla* was of the same signifi-

[1] *Fertilization of Flowers*, p. 251.

cance. The honey bee was observed to visit the red flowers both when solitary and when associated with yellow flowers. Neither was there any preference manifested for yellow flowers when flowers of both colors occurred in the same cyme. Examination showed that the reddish flowers continued to secrete honey abundantly. This is an instance, not uncommon, of a flower secreting nectar longer than is necessary. The stems and leaves are frequently reddish, due probably to oxidation, and the reddish color of the older flowers appears to be due to a similar change in the nutritive fluids.

The flowers are proterogynous. Immediately after the apices of the corolla separate, the stigma protrudes in a receptive condition. At this stage the anthers, which are 4 mm. long, rest directly against the style, the length of which is then 13 mm. and of the stamens 12 mm.; in the older flowers the style lengthens to 19 mm., the stamens to 15 mm. The anthers dehisce introrsely shortly after the expansion of the flower, but as they are shorter than the style, self-fertilization is not likely to occur. As the style lengthens it is bent aside, and the honey bee was observed to visit flower after flower without coming in contact with the stigma.

The length of the corolla tube (7 mm.) and the fact that the anthers are divergent and not in close proximity to the stigma indicate that the flower is adapted to bumblebees. The smaller bee, *Halictus disparalis* Cr., ♀, was seen to try vainly to reach the honey. The most frequent visitor, however, is the honey bee. The larva of the hawk moth, *Hemaris diffinis*, feeds upon the leaves, and the moth sucks the flowers. Minute flies and a beetle were observed feeding upon the pollen.

Visitors: Hymenoptera — Apidæ: (1) *Apis mellifica* L., ♀, sucking, frequent; (2) *Bombus bimaculatus* Cr., ♀, s.; (3) *Psithyrus* (*Apathus*) *laboriosus* Fab., ♀, s.; Andrenidæ: (4) *Halictus sp.;* (5) *H. disparalis* Cr., ♀, collecting pollen; (6) *Halictulus americanus* Ash., ♀; (7) *Augochlora aurata*, Sm., ♀, c. p. None common except the first.

Lepidoptera — Rhopalocera: (8) *Pamphila peckius* Kirby, s.; Heterocera: (9) *Hemaris diffinis*, s., standing on a leaf or poising on the wing. June 29 to July 6. Waldoboro.

Weigelia Thun.

The eastern Asiatic species of Weigelia are often referred to Diervilla, but are regarded as distinct by Britton.[1] An immense number of varieties have been produced in cultivation by selection and hybridization, which are remarkable for their wide range of coloration. There are white and deep-red forms with every intermediate shade; white when opening but changing to rose; deep red in bud but rose-colored in bloom; flower pale rose at first, changing to deep red; yellow; light yellow, changing to white; pale yellow, changing to pale rose; and reddish-purple. The leaves are also frequently highly variegated with yellow and white.

Weigelia rosea Lindley.

The trumpet-shaped flowers were observed by Müller in Germany to be visited by *Osmia rufa* L., ♀, and also by *Halictus leucopus* K., ♀, and *H. sexnotatus* K., ♀. These small bees creep into the corolla tube, the mouth of which is 8 to 10 mm. in diameter, to obtain the nectar. They come in contact first with the stigma, which surpasses the anthers, and then with the pollen-covered anthers. The flowers are stated to be proterogynous, but not to the exclusion of self-fertilization. Knuth saw *Bombus agrorum* F., ♀, frequently visit the flowers in his garden. There is not, however, sufficient room for the larger bees to enter the flower conveniently.[2]

[1] Britton and Brown, *Illustrated Flora*, vol. iii, p. 242.

[2] Knuth, *Handbuch der Blütenbiologie*, Bd. ii, Nr. 1, p. 525.

REVIEWS OF RECENT LITERATURE.

ANTHROPOLOGY.

Anthropological Notes. — In the *American Anthropologist* for July, Dr. J. Walter Fewkes describes the Alósaka cult of the Hopi Indians. His conclusions are, in part, as follows: "There survives in the Hopi Ritual a worship of horned beings, called Alósakas, which once existed at the now ruined pueblo of Awatobi." "The purpose of the rites performed in this cult is to cause seeds, especially corn, to germinate and grow, and to bring rain to water the farms." "The Alósaka cult is a highly modified form of animal totemism, and the Alósaka represents the mountain sheep."

Professor A. C. Haddon publishes an account of the Cambridge Anthropological Expedition to Torres Strait and Sarawak in *Nature* of August 31. It is stated that the scientific results obtained by the seven members of the party will be published in a series of memoirs which will be obtainable separately. Dr. Rivers and Messrs. Myers, McDougall, and Seligmann will write the volume on experimental psychology; Mr. Ray is said to have ample matter for a volume on linguistics. Professor Haddon will deal with the physical anthropology of the natives of Torres Strait and New Guinea. Music, religion, medicine, statistics, architecture, etc., will be treated by the several members of the party. A large number of excellent photographs were taken.

An illustrated article appeared in the July number of *Monumental Records*, in which Mr. Geo. H. Pepper described the ceremonial deposits found in an ancient pueblo estufa at the Pueblo Bonito in the Chaco Cañon. The Hyde Expedition, of which Mr. Pepper is the director, has worked several seasons at that extensive group of ruins, and the explorations are to be continued. The discovery of ceremonial objects is said to be the first reported from any pueblo ruin.

In the September-October number of the *American Antiquarian*, William P. Blake publishes a brief account of the aboriginal turquoise mines of Arizona and New Mexico. He mentions a few of the localities from which turquoise has been obtained, but refers the reader

to the treatise, by Geo. F. Kunz, on "Gems and Precious Stones of North America," for further information. The author maintains that the Nahuatl term "chalchuitl" referred to turquoise and not to jade and emerald, as stated by E. G. Squier. We note that Brinton, in his "Prehistoric Archæology," applies the term "chalchuitl" to jade alone.

In the same journal A. F. Berlin describes a valuable collection of terra-cotta antiquities from the land of the Incas, and incidentally mentions the fact that these rare specimens had been safely transported long distances by the careful and friendly natives, but were broken and otherwise injured by the New York custom inspectors.

The first number of Vol. I of the *Memoirs of the Bernice Pauahi Bishop Museum of Polynesian Ethnology and Natural History* is devoted to Hawaiian Feather Work. The director of the museum, W. T. Brigham, refers to the early voyagers who found the art of feather working in a flourishing state in Hawaii during the latter part of the last century; he then describes and furnishes illustrations of the birds from which the feathers are obtained; the helmets, cloaks, and other articles of feathers are described in more or less detail, and lists are given of the specimens now known to exist in the various museums of the world. The monograph is very fully illustrated, two of the plates being in colors.

GENERAL BIOLOGY.

Physics of Cell Life. — Realizing the prematureness of any present attempt at a chemical understanding of cell phenomena, and believing that there is a large field for interpretation upon a purely physical basis, Dr. L. Rhumbler has devoted himself to a most promising line of investigation — the study of the physics of the cell as explanation of its phenomena; an attempt to analyze cell life, as far as may be, into physical components, leaving the ultimate chemical problems for the future. His previous papers deal with the shell-making of the rhizopods and with cell division; the present,[1] with some of the phenomena of distribution of pigment in eggs and early larvæ.

Assuming that protoplasm is a foam, much as claimed by Bütschli, and that the nucleus and the centrosomes at certain times absorb

[1] Physikalische Analyse von Lebenserscheinungen der Zellen II, III, *Archiv f. Entwick. d. Organismen*, Bd. ix, Sept. 5, 1899, pp. 32–100, Pl. IV.

liquids from the foam, he has argued the necessary occurrence of many of the phenomena of cell division. On the same basis he now attempts to account for the distribution of pigment in many cases.

With the aid of pressure experiments upon the yolk of the hen's egg, the use of his system of elastic bands, and of the interesting gelatine models devised by Bütschli, the author endeavors to support an application of his views to the phenomena described by Fischel in 1899. Fischel placed live eggs of echinoderms in very weak solutions of neutral red, and found that minute granules became stained all through the egg. When the egg divided, these granules were concentrated about the nucleus and in the spindle stage formed a dumbbell-shaped mass; later they were again more uniformly distributed. Rhumbler endeavors to show that this apparent motion of the granules was not due to actual migration, and then explains it as a result of the drying effect postulated in his theory. If the nucleus absorbs water from the neighboring foam, the lamellæ of that foam will become denser and the contents of the alveoli smaller, and large bodies, such as yolk spherules, be squeezed away from such a region of increased pressure. Small bodies may, however, remain, provided they have sufficient adhesion to the alveolar lamellæ. This he assumes to be the case with the minute stained granules. In the region about the nucleus, where water is absorbed and from which large granules are forced away, there will be a condensation that must bring the granules nearer together if they stick to the shrinking lamellæ. The crowding of granules about the nucleus is thus due to a diminution in mass of material and not to a migration of granules from afar.

The author next takes up the arrangement of normal pigment in the eggs of Amphibia. The well-known dark streak that marks the path passed over by the sperm moving within the frog's egg is due, he maintains, not to any attraction on the part of the sperm, nor to any manufacture of new pigment, nor to any other chemical process, but simply to the physical stress produced by the passage of a body through a foam. The sperm adheres to the foam framework and tends to pull it along; the resulting tension behind the sperm leads to outflow of the more liquid contents of the alveoli, and a shrinkage of the framework that draws the adherent pigment granules nearer together.

The pigment is thus concentrated behind the sperm much as the colored granules were concentrated about the nucleus in Fischel's experiments. The granules remain in the region of tension and

diminished volume and so are nearer together; they do not travel to such regions.

Though the reader may not be convinced of the necessity of this explanation, it is certainly most interesting to learn that bubbles of air squeezed through mashed egg masses, and even through artificial mixtures of soot and emulsions, do leave pigmented tracks behind, similar to the sperm track. Some physical explanation of the pigmented sperm track seems forced upon us.

The author then takes up the concentration of pigment upon part of the surface of the frog's egg; the aggregation of pigment about the nucleus in cleavage stages of the frog's egg; the remarkable rearrangements of pigment in isolated cells of frog's eggs when "cytotropic" movements bring them together again; the arrangements of pigment in blastulæ of triton after injury by pressure; and the normal arrangement of pigment in certain cells of the triton in the stages of gastrulation and of formation of neural ridges.

In all cases he applies the same formula: pigment collects in areas of increased pressure and of condensation.

When cells are in active chemical interchange there will be greater adhesion of their applied surfaces and less cohesion of the part of each turned towards its neighbor. The parts of the cells most removed from such interchange will be those of relatively high tension, and in these the pigment, if present at all, may be concentrated by adhering to the shrinking lamellæ. Pigment will be on the denser and chemically inactive sides of cells.

In early stages of development pigment does not indicate active chemical changes where it is found, nor is it of any direct use; it remains inert and is concentrated in areas of condensation or may even be expelled from active areas.

Secondarily, natural selection may have emphasized its occurrence in some places where it happened to be of use.

Aside from the main issue, the author's evidence that invagination and evagination are due to actions of individual cells seems specially interesting. E. A. A.

Biological Lectures. — The substantial character of the work done at the Marine Biological Laboratory at Woods Holl is evinced by the recently published volume of *Biological Lectures* for 1898.[1] The sixteen lectures thus brought together are by well-known authorities, and touch on one side or another almost all the important biological

[1] *Biological Lectures, from the Marine Biological Laboratory, Woods Holl, Mass., 1898.* 343 pp. Ginn & Company, Boston, 1899.

problems of the day. The opening lecture is on the structure of protoplasm, by E. B. Wilson, whose study of the living echinoderm egg has led him to revise his former opinion and declare himself now in favor of the alveolar structure of protoplasm. Too much stress cannot be laid upon the importance which the author ascribes to the study of living protoplasm as a check upon what we assume to be a satisfactory preservation of it by histological means. Five lectures deal with problems of cell lineage: the homologies of cells and cell groups are discussed by E. B. Wilson; the interpretation of the various kinds of egg cleavage as adaptations of the egg is taken up by F. R. Lillie; the importance of protoplasmic movement in the distribution of materials from the nucleus is emphasized by E. G. Conklin; equal and unequal cleavage in annelids is treated by A. L. Treadwell, who points out that those organs which appear early in ontogeny are usually represented by large-bodied cells, irrespective of the distribution of yolk; the origin of the prototroch is considered by A. D. Mead. Closely related to these subjects are C. M. Clapp's lecture on the relation of the axis of the embryo to the first cleavage plane, which is dealt with from the modern experimental standpoint, and T. H. Montgomery's account of the nucleolus. The possible relations of contractility and phosphorescence are pointed out by S. Watasé, who argues for the view that phosphorescence may be a general property of living protoplasm. T. H. Morgan, in considering some of the problems of regeneration, points out the apparent inefficiency of purely mechanical explanations, and suggests to students the importance of keeping the vitalistic standpoint in view. Problems in evolution are represented by H. C. Bumpus's interesting examination of a large number of English sparrows killed in a severe winter storm; the birds eliminated were in one respect or another far removed from the typical form. The question of heredity is dealt with by J. Loeb, as illustrated in the markings of fish embryos, and the present necessity of an analytic treatment is enforced. Paleontology is represented by W. B. Scott's account of North American ruminant-like mammals. An appreciative historical review of Wolff's *Theoria generationis* is given by W. M. Wheeler. Animal psycho-physiology is represented by W. W. Norman's very interesting paper on the question whether the reactions of lower animals due to injury indicate sensations of pain, and C. O. Whitman's elaborate account of the habits of leeches, salamanders, and pigeons. The volume is concluded with brief memorial notices of J. I. Peck, J. E. Humphrey, and W. W. Norman.

G. H. P.

ZOÖLOGY.

Kingsley's Vertebrate Zoölogy. — That the study of vertebrate anatomy in America has passed the period of pure comparison and entered that of a more scientific morphology has become evident by the appearance of a recent work by Dr. John Sterling Kingsley,[1] who thus gains the honor of producing the first American text-book on the subject.

By this we do not mean that there has been any lack of special investigation in the field of vertebrate anatomy, but, as stated in the preface of the work under consideration, "observation and uncorrelated facts do not make a science," and a comprehensive text-book which collects in a system the results of this series of investigations has hitherto been lacking in our literature. The place of such a work has been supplied up to the present time by European text-books, among which may be first mentioned the *Grundriss* of Wiedersheim (latest edition 1898) and the new edition of Gegenbaur, of which the first part has just appeared; but in these the disadvantage of a foreign language, the lapse of time which must necessarily ensue before they can appear in translation, and the exotic character given by the frequent references to animals exclusively European emphasize the need of an American manual illustrated by American material. In this respect it becomes a matter of satisfaction to glance through the pages of Kingsley's work and find Acanthias, Necturus, Amblystoma, and Sceloporus in place of Scyllium, Proteus, Salamandra, and Lacerta.

The object of the book, as stated by the author, is "to supplement both lectures and laboratory work and to place in concise form the more important facts and generalizations concerning the vertebrates," and its employment as collateral reading for the student will emancipate the lecturer from the necessity of continually reiterating the elementary principles of the subject. Its use in the laboratory, also, where it will assist the student in finding out what he wishes to know, will be a pleasing change from the usual laboratory manual, with its too carefully tabulated series of observations, a style of literature which it is as easy for an author to write as it is difficult for another to follow.

In arrangement Dr. Kingsley's text-book is divided into two parts,

[1] Kingsley, J. S. *Text-Book of Vertebrate Zoölogy.* New York, Henry Holt & Co., 1899.

the first being morphological, and the second systematic. In the first part the work is based entirely on embryology, and an introduction which sketches the main features of development is succeeded by the morphology of the organs arrayed in accordance with the germ layers. Although logically there is much to be said in favor of such an arrangement, it would seem hardly an improvement on the usual method, which begins with the skeleton and muscles, and thus presents a framework that may serve as a series of relations by means of which the other systems may be more easily described. Although permissible for an elementary text-book of general morphology where there is little or no descriptive anatomy, it would not seem possible to employ such an arrangement in a work upon the anatomy of a single animal, for historically the nomenclature of the bones was the first established, and organs and parts of organs have been named with reference to these, or to other parts which, in the usual order, precede them. A second difficulty is that it is impossible to remain consistent to such a plan, or if strict consistency be carried out, it is then necessary to separate most widely organs which should be treated together. Thus, in the treatment of gills (p. 22), it becomes logically advisable to speak of the external "gills" of amphibians which are strictly ectodermic and which, with due regard to the arrangement of the book, should come in with the integument (about p. 90). Again, scales are treated under the division "ectodermal structures," but these include the scales of teleosts which, in their completed state, are entirely mesenchymatous, and also the scales of Selachians which possess a double origin. The subject of teeth, though strictly homologous with the latter organs, appears with the "endodermal organs," although their origin is made clear in the text, while dermal or membrane bones are treated under "skeleton." It is of course impossible by any arrangement always to bring correlated parts into close juxtaposition, but an arrangement which separates so widely three such closely related structures as placoid scales, teeth, and dermal bones is certainly unfortunate.

In the arrangement and nomenclature of the embryonic layers, the author has employed the very convenient terms "mesothelium" and "mesenchyme" for the two structures which arise between ectoderm and endoderm, and thus leaves the word "mesoderm" to be employed as a comprehensive term for both structures. It remains to be seen, however, whether the replacement of the terms "invagination" and "evagination" by the Saxon "inpushing" and "outpush-

ing" will be more favorably received than have been the many attempts to find a substitute for the German "Anlage."

The verbal nouns referred to must imply such verbs as "to inpush" and "to outpush," and these forms are, as a matter of fact, employed, as, for instance (p. 19), "becomes inpushed into the deeper layers," but upon the same page the expression "pushed inside" and also the noun "ingrowth" appear, thus causing some confusion.

A characteristic which impresses one especially favorably is the extreme conciseness and concentration shown in the entire work, which, at the same time, does not prevent the description from being more than usually clear and comprehensive. An especially good illustration of this is seen in the morphological description of the skull, in which the entire subject is covered within the limits of seventeen pages, and yet every essential point is fully treated (pp. 150–167).

The second part of the work is called the "Classification of Vertebrates," but in reality it gives not only the enumeration of the groups, but also presents so many anatomical details that it may be used as a special comparative anatomy filled with the details which were not possible in the first part. Thus, if a student is in search of a special point in the anatomy of any animal, he should first read the morphological description of the organ as given in the first part, and then turn successively to the descriptions of the class, order, and the smaller subdivisions within which the animal in question is found. This seems an excellent arrangement and may be the cause of the extreme conciseness of the first part, as it avoids clogging the exposition of the theories with concrete examples, as in the majority of the text-books on the subject. Especially noticeable in the second part is the treatment of the reptiles, which are completed by the addition of the fossil orders; and that of birds, which gives the new classification founded upon anatomical characters.

The work is illustrated by 378 text-figures, of which about 150 are original and new.

Recent monographs have contributed several which thus appear for the first time in a text-book (Ex. Figs. 120, 139, 160, 161). Among the new figures there are some exceptionally clear diagrams, such as Figs. 35, 61, 62, 110, and a series illustrating the relationship of the various cavities of the body (Figs. 111, 127, etc.).

At places where we are accustomed to meet certain time-worn figures there is some relief in finding either a new object employed or,

at least, new figures representing the old object (Ex. Figs. 4, 6, 116, 118, 140).

There is a small number of the inevitable verbal errors, of which may be noted : *foramen lacerus anterior* (p. 164), Fascia used as a plural (p. 112), and Malapterus (p. 115).

A New Text-Book on the Nervous System. — No field of zoölogical research has been more assiduously cultivated or has yielded more important results in the last decade than the nervous system. While the cell theory and the interpretation of most tissues in conformity with it are matters of history, the conception of the nervous system as an association of cells dates really from 1891. With the enunciation of the neurone theory by Waldeyer in that year, a new era in the study of the nervous system began ; and though this theory may require modification even in some fundamental respects, it has been undoubtedly a most important factor in bringing order into what was neurological chaos. The result of this clarifying influence has been, not only an enormous productivity in effective research, but the appearance of several high-grade text-books dealing with the nervous system from the new standpoint. Ramon y Cajal's well-known brochure heads the list as the first consistent attempt to describe the nervous system of the higher animals as an aggregate of neurones. The same principle was adopted in van Gehuchten's text-book, and to a less extent in the more conservative treatises by Edinger and by von Lenhossék, and is accepted by the well-known American neurologist, L. F. Barker, in his new text-book entitled *The Nervous System and its Constituent Neurones.*[1]

The book, though divided into six sections, which are further subdivided into chapters, falls naturally into two parts : the first, comprising the first five sections of a little over 300 pages, contains a general account of the structure and physiology of the nervous unit or neurone ; and the second, including only the sixth section of some 650 pages, presents a descriptive account of the groups of neurones constituting the nervous system of man and other higher mammals.

To the general reader the first five sections are naturally the more interesting. The first section is given to an historical account of the development of the neurone concept. This opens with a description

[1] Barker, L. F. *The Nervous System and its Constituent Neurones*, designed for the Use of Practitioners of Medicine and of Students of Medicine and Psychology. New York, Appleton & Co. xxxii + 1122 pp., 676 illustrations, and 2 colored plates.

of the diffuse nervous network, supposed by Gerlach to be the means of communication between the nervous elements, and is followed by an account of the discoveries made chiefly by the Golgi and the Ehrlich methods, whereby investigators were led to abandon Gerlach's views. By this course the reader is led up to the full statement of the neurone theory by Waldeyer in 1891. The concluding chapter of this section deals with the objections which have been raised to the theory since its promulgation. The foundations of the theory are fourfold: first, it is *a priori* probable that the nervous system, like other parts of the body, is a cellular system; secondly, it is well established that the embryonic nerve cells are as distinct from one another in the beginning as any other cells; thirdly, the nutrition of the nervous elements, as shown in their degeneration, etc., is most readily understood on the grounds of this theory; and, fourthly, the selective staining of elements as seen in Golgi and in Ehrlich preparations accords well with this view. The objections raised against the theory are regarded by the author as relatively slight. The union of nerve cells through their processes, as seen occasionally by observers such as Dogiel, is regarded as no more objection to the general theory than Siamese twins are to the idea that the human species is made up of separate individuals. The results of Apáthy's studies, according to which a network much as Gerlach believed in is claimed to exist, are stamped with "Not proved"; and the author states that even should they prove true they afford no grounds for a serious criticism of the theory.

The second section deals with the external morphology of the neurone. The classification of cell processes into axones and dendrites is generally accepted, and only a hint is now and then given that the conditions in the lower animals show that this distinction is one of a very questionable nature and certainly not fundamental. The interrelation of neurones through contact only and the so-called "retraction theory," so much in vogue with certain classes of psychologists, are put in their true light as a matter of great uncertainty.

The third section, on the internal morphology of the neurone, is a masterful presentation of one of the most confused and intricate problems of neurology. The interpretation of conflicting results on the basis of differences in methods and the sweeping away of difficulties arising from a confusion in terminology are admirable features of this part of the work. In one respect only is the author less happy in his treatment of the subject. He expresses the belief that many of the problems of the finer anatomy of nerve cells must wait for

solution till more definite knowledge can be gained of the structure of cells in general. To us it seems that the nerve cell is one of the best cells in which these problems can be attacked.

The section on the histogenesis of nerve tissue is less satisfactory than any of the preceding, because too little is given on histogenesis and too much on the topographical development of the vertebrate nervous system. The subject of the development of nerve fibres is only touched, and the differentiation of the various forms of nerve cells receives little attention. A very full account of the segmental arrangement of the spinal nerves and their relation to the musculature is given.

The physiological and pathological aspect of the neurone is treated in the fifth section. The metabolism of the nerve cell, as illustrated by the degeneration of its fibres when cut from it, is well described, and emphasis is justly laid on the lately discovered changes shown in cells from which fibres have been separated. The equally important subject of the regeneration of nerves is passed over with very few words. Reasons are brought forward to show that neurones in life are under slight but continuous stimulation, and that all parts of the neurone, including the dendrites, are more or less concerned with true nervous functions. The nature of nervous impulses is not discussed, but their directions so far as the cell body is concerned are shown to be not subject to such simple laws as have been formulated. This section concludes with an excellent résumé of the visible effects of fatigue and poisons on nerve cells, and a brief consideration of the means by which the cell body influences the nutrition of the distant parts of its fibres.

The sixth section includes an exhaustive account of the groups of neurones making up the human nervous system. Its five subsections deal with the following groups: sensory neurones of the first order; sensory neurones of the second order; lower motor neurones; upper motor neurones; and projection, commissural, and association neurones.

While every student of neurology will be thankful to the author for the thoroughgoing way in which he has carried out his undertaking, and for the admirable clearness with which he has set down his results, the work is not without its faults. Chief among these is the very general absence of reference in the more introductory sections to the results of neurological study in the lower animals. While the comparative novelty of this field may be some excuse for its neglect, the part it has played in setting in a right light many of the general

problems which have arisen in the neurology of higher forms shows that one cannot afford to neglect it.

A second and perhaps less pardonable fault is the absolutely unqualified way in which the neurone theory is accepted and the light manner in which really serious objections to it are passed over. To read the author's presentation of Apáthy's work one would think that this investigator's results were almost in line with the neurone doctrine ; but an unbiased comparison shows this not to be true. Surely the statements of Apáthy, if correct, are more serious obstacles to the acceptance of the neurone theory than Barker is willing to admit ; and what is perhaps less consoling to an advocate of the theory is that these statements have received no small amount of confirmation at the hands of Bethe.

The letterpress and numerous illustrations are excellent, and the volume is provided with two indices — one for subjects and the other for authors. In the subject index the two kinds of type used in the page numbers refer, we are told, in one case to text and in the other to figure reference ; in the author's index two kinds of type are also employed, but, probably through an oversight, no explanation of their use is given.

The defects which the book has are few compared with its excellencies, and we do not hesitate to pronounce it a masterly production of the highest quality of which Americans may justly be proud.

G. H. P.

Neurone Theory. — A very interesting and timely brochure on the neurone doctrine and its opponent has come from the pen of A. Hoche.[1] The author gives a clear statement of the foundations of the theory, and then considers it in the critical light of recent discovery. His conclusions are that the neurone theory in its original form is no longer tenable, and that the fibrillar theory must replace it, so far as the histology of the adult nervous elements is concerned. The nervous elements develop as independent cells, and become secondarily connected by fibrillar growths, though in this later condition they reassert their physiological independence in the various aspects of their metabolism. The histogenesis and physiology of nervous elements, particularly their trophic relations, follow then on the lines laid down by the neurone theory, and in these respects this theory may still be said to be valid.

G. H. P.

[1] Hoche, A. Die Neuronenlehre und ihre Gegner. 51 pp. A. Hirschwald, Berlin, 1899.

Polytomous Nerve Fibres. — Dr. E. Ballowitz[1] has found that the enormous electric nerve fibres of the electric catfish of the Nile, Malapterurus, do not branch as ordinary medullated fibres do, but divide at once into from four to nine trunks. The most usual numbers were five or seven, the even numbers, six and eight, being less frequent. The resulting fibres varied much in calibre, but were always thinner than the main fibre, which, however, was not so large in cross-section as the derived fibres taken collectively. A derived single fibre may branch again dichotomously or trichotomously, as ordinary fibres do. The condition shown in the division of the main fibre in Malapterurus is intermediate between that found in ordinary nerve fibres and in the electric ray, Torpedo, where the branches vary between fifteen and twenty-five.

G. H. P.

Nerve Cells of the Human Cortex. — Helen B. Thomson[2] has undertaken some interesting computations concerning the composition of the brain in man. She finds that the total number of functional nerve cells in the cerebral cortex of an adult man is in round numbers ninety-two hundred millions, and yet the volume of these is only 1.37% of the whole cortex. The number of giant cells in the cortex corresponds almost exactly with the number of pyramidal fibres passing to the spinal cord, and hence the pyramidal fibres are probably the processes of these cells.

G. H. P.

The Fur Seals and Fur Seal Islands. — The third volume of the voluminous report on the Fur Seal and the Fur Seal Islands, by Dr. David Starr Jordan and his associates, is just issued from the Government Printing Office. The first two volumes, issued some time since, relate to The Fur Seal of the Pribilof Islands: its History, its Natural History, and its Fate. The fourth volume, already issued, consists of Dr. Leonhard Stejneger's report on The Fur Seal Islands of Russia and Japan.

The present volume is due to the enlightened interest of Mr. Charles Sumner Hamlin, then Assistant Secretary of the Treasury, who instructed the Commission to use all possible effort to complete our knowledge of the fauna and flora of the regions visited.

The present volume of 630 quarto pages is devoted almost entirely

[1] Ballowitz, E. Ueber polytome Nervenfaserteilung, *Anat. Anzeiger*, Bd. xvi, pp. 541–546.

[2] Thomson, H. B. The Total Number of Functional Cells in the Cerebral Cortex of Man, etc., *Journ. of Comp. Neurology*, vol. ix, pp. 113–140.

to the natural history of Bering Sea. It was prepared under Dr. Jordan's direction, under the editorial supervision of Mr. Frederic A. Lucas. It contains the following articles, most of them fully illustrated:

1. "The Main Divisions of the Pinnipedia," by Mr. Lucas. In this paper the distinctions between the Otariidea, or eared seals (with the walrus), and the Phocoidea, or true seals, are fully developed.

2. "The Species of Callorhinus, or Northern Fur Seal," by Dr. Jordan and Mr. George A. Clark, Secretary to the Commission. In this paper three closely related species or subspecies are indicated and named, corresponding to the three well-known herds. These are *Callorhinus ursinus* (*L*), the fur seal of Komandorski, *Callorhinus alascanus*, the fur seal of the Pribilofs, and *Callorhinus curilensis*, the fur seal of Robben Island and the Kuriles. As the differences are slight, these may well be regarded as subspecies, but from the nature of things they do not intergrade. The generic name Callorhinus is retained as sufficiently distinct from the earlier Callorhina, the two words being spelled differently. Those who hold otherwise may call the fur seal Callotaria Palmer.

3. "Variations in Size and Color of the Fur Seal," by Mr. Lucas.

4. "Dentition of the Fur Seal," by Mr. Lucas.

5. "Anatomy of the Fur Seal," by Robert E. Snodgrass.

6. "Brain of the Fur Seal," by Dr. Pierre A. Fish.

7. "Breeding Habits of the Fur Seal," by Mr. Lucas.

8. "Food of the Fur Seal," by Mr. Lucas. This is shown to consist mainly of the seal-fish (*Therobromus callorhini*), a species of smelt hitherto undescribed, of the Alaskan pollock (*Theragra chalcogramma*), and of a squid (*Gonatus amœnus*). Practically no species available as human food are commonly eaten by the fur seal.

9. "Mental Traits of the Fur Seal," by Mr. Lucas.

10. "Causes of Mortality among Fur Seals," by Mr. Lucas.

11. "Internal Parasites of the Fur Seal," by Charles Wardell Stiles and Albert Hassall. Of these the most important is the strongyle worm, Uncinaria, which destroys large numbers of the seal pups on the sandy rookeries on St. Paul. The eggs of this worm lie in the sand, adhere to the fur of the mother, and are swallowed by the young. Most of the rookery ground is rocky, but on sandy tracts, as on parts of Tolstoi and Zapadni rookeries, the mortality is very great, the pups affected dying of anæmia. In this paper fourteen species of Ascaris are described besides the Uncinaria and a small tapeworm.

12. "The Beasts of the Sea," a translation from Steller's original account by Professor Walter Miller. This remarkable work (De Bestiis Marinis), published in 1751, gives the first account of the sea cow, the sea otter, sea lion, and sea bear, or fur seal.

13. "The Sea Bear," a translation of an essay by Bishop Ivan Veniaminof, 1839, by Dr. Leonhard Stejneger.

14. "Pelagic Sealing," by Charles H. Townsend, a valuable collection of observations and records.

15. "Notes on the Fur Seals of Guadalupe, Galapagos, and Lobos Islands," by Mr. Townsend. This article and the preceding are illustrated by excellent photographs.

16. "Descriptions of the Guadalupe Seal, Arctocephalus townsendi," by Dr. C. Hart Merriam.

17. "Exploration of Guadalupe Island," by Dr. Wilbur W. Thoburn.

18. "Insects of Guadalupe," by William A. Snow.

19. "Plants of Guadalupe," by Professor William Russell Dudley. One new species, *Talinum guadalupense*, is described.

20. "Cruise of the *Dora Siewerd*" (sealing schooner), by A. B. Alexander.

21. "Fur-Seal Hunting in the Southern Hemisphere," by Dr. J. A. Allen.

22. "Rookery Maps of the Pribilof Islands," by Lieut.-Comm. J. F. Moses, U. S. N.

23. "Branding of Seals," by Dr. Jordan and Mr. Clark.

24. "Electrical Branding," by Elmer E. Farmer.

25. "Branding Experiments on St. Paul," by Colonel Joseph Murray.

26. "Branding Experiments on St. George," by Mr. James Judge.

27. "The Blue Fox (*Vulpes lagopus*)," by Dr. Jordan and Mr. Clark.

28. "Mammals of the Pribilof Islands," by Frederick W. True.

29. "Birds of the Pribilof Islands," by William Palmer. Sixty-nine species enumerated, with valuable notes and plates.

30. "Fishes of Bering Sea," by Dr. Jordan and Dr. Chas. H. Gilbert. Two hundred and twenty-nine species enumerated, with notes and numerous plates. The numerous species are all included in Jordan and Evermann's "Fishes of North and Middle America."

31. "Fishes of Arctic Alaska," by Norman B. Schofield. Notes on thirty-eight species, two, *Argyrosomus alascanus* and *Liparis herschelinus*, being new.

32. "Tunicates of the Pribilof Islands," by Dr. William E. Ritter. Eleven species described and figured, ten being new. These are *Styela greeleyi*, *Dendrodoa tuberculata* and *D. subpedunculata*, *Polyclinum globosum* and *P. pannosum*, *Aplidiopsis jordani*, *Amaroucium kincaidi*, *A. pribilovense*, and *A. snodgrassi*, and *Synoicum irregulare*.

33. "Mollusks of the Pribilof Islands," by Dr. William H. Dall.

34. "Insects of the Pribilof Islands," by E. A. Schwartz.

Two seal ticks are described as new, *Hæmatopinus callorhini* and *Ixodes arcticus*, in a supplemental note by Professor Herbert Osborn.

35. "Crustacea of the Pribilof Islands," by Mary J. Rathbun. *Crangon communis*, *Nectocrangon crassa*, *Spirontocaris barbata*, and *Spirontocaris avina* described as new.

36. "Plants of the Pribilof Islands," by James M. Macoun. With notes and plates.

37. "Algæ of the Pribilof Islands," by Dr. W. A. Setchell. Thirty-eight species noted.

Many of these papers deserve more extended notice or review, but this note may serve as an index to them.

D. S. J.

Fishes of the Potomac River. — In the *United States Fish Commission Bulletin* for 1898, Dr. Hugh M. Smith and Mr. Barton A. Bean give a valuable list of the fishes found in the waters of the District of Columbia, with notes on their distribution. Eighty-one species are enumerated.

D. S. J.

The Reappearance of the Tilefish. — In May, 1879, Captain Kirby, of Gloucester, discovered in the deep waters south of Nantucket a very remarkable fish, brilliantly colored and of high value as food. This fish was described by Goode and Bean as *Lopholatilus chamæleonticeps*, and the common name of the tilefish was suggested by Dr. Goode. This name alludes to its tile-like coloration, being also an available syllable of Lopholatilus, its scientific name. In 1882 vast numbers of tilefish were killed by a cold storm, and were found floating in the Gulf Stream. Since that time the species has not been seen until 1897 and 1898. The explorations of the Grampus under the auspices of the United States Fish Commission show that the species now occupies its original range, having recovered from the partial extermination of 1882. A full record of these investigations is given by Dr. Hermon C. Bumpus in the *Bulletin of the United States Fish Commission* for 1898.

D. S. J.

The Nervous System of the Bony Fishes. — Dr. C. Judson Herrick, of Denison University, contributes to the *Bulletin of the United States Fish Commission* for 1898 a valuable study of the peripheral nervous system in bony fishes.

D. S. J.

A Filefish New to the United States. — Dr. Hugh M. Smith, in the *Bulletin of the United States Fish Commission* for 1898, describes and figures a species of filefish new to the waters of the United States, and which he refers to *Alutera monoceros*, a species of the Indian Ocean and tropical Pacific. The specimen was taken at Woods Holl by Mr. Vinal N. Edwards, and is evidently like so many others found in this locality, a straggler brought from the West Indies by the Gulf Stream.

Fishes now referred to *Alutera monoceros* have been described under very many different names, and it is highly probable that more than one species is included under this title. A species of this type has been described by Poey, from Cuba, under the name of *Alutera güntherina.* The latter species has not been since seen. It is scantily described, and if words and plates can be trusted, it differs from Dr. Smith's fish in the higher spine and truncate caudal fin. It is probably not the same species, in which case two species of short-tailed Alutera exist in our waters besides the long-tailed *Alutera schœpfi*, *punctata*, and *scripta.* In any event this species is an interesting addition to our fauna, whether it be *Alutera monoceros* or a species distinct. D. S. J.

Fishes of Kadiak Island. — Mr. Cloudsley Rutter, now assistant to the United States Fish Commission, made in May, 1897, a fine collection of the tide-pool fishes in the vicinity of Karluk. This collection is described in the *Bulletin of the United States Fish Commission* for 1898. Fourteen species are enumerated, two of which are new, besides a third, *Neoliparis rutteri*, described as new by Gilbert and Snyder in Jordan and Gilbert's "Fishes of North and Middle America." The new species, which are well figured, are *Sigmistes caulias* and *Porocottus bradfordi.* Sigmistes is a new genus allied to Oligocottus, with a smooth body, arched lateral line, and very long dorsal. The single preopercular spine is hooked upward. D. S. J.

Fishes of the Congo. — Dr. G. A. Boulenger, of the British Museum, has issued the fourth fascicle on new fishes of the Congo, containing species of Polypteridæ, Clupeidæ, Mormyridæ, and Characinidæ, with detailed descriptions and excellent plates. D. S. J.

Fishes of Florida. — In the *Report of the United States Fish Commission* for 1899, Dr. B. W. Evermann and Dr. W. C. Kendall give a check list of the fishes of Florida, with references to all notices of the localities of each species, and also a complete bibliography. Five hundred and seventy-six species are enumerated, which shows the thoroughness with which that interesting region has been explored. The paper furnishes an admirable model as a faunal catalogue, and it has great value to the student of geographical distribution. D. S. J.

Günther on the Fish Collections of Linnæus. — The account of the fishes, as given by Linnæus in the *Systema Naturæ*, is based

almost solely on the writings of other authors, notably those of his associate and close friend, Peter Artedi, the "father of ichthyology." There was, however, in Linnæus's possession a small collection of fish skins, the most important of these containing seventy-one species, having been sent from Charleston, South Carolina, by Dr. Alexander Garden.

Most of this collection is now preserved in the Collection of the Linnæan Society of London. Dr. Albert Günther, president of this society, in a recent address, has given an account of each of these specimens. This account is in greater detail than one given in 1886 by Messrs. Goode and Bean, and some of its conclusions have an important bearing on the nomenclature of North American fishes.

The examinations of Dr. Günther necessitate the following changes from the names lately accepted by Jordan and Evermann: *Felichthys felis* (Linnæus) for the Gaff topsail catfish, instead of *Ailurichthys marinus* (Mitchill); *Galeichthys milberti* (Cuv. and Val.), instead of *G. felis;* if Dr. Günther's identification of *Siluris felis* is correct, which we cannot doubt, it is strange that Linnæus counted six barbels when but four exist; *Epinephelus guttatus* (Linnæus), instead of *E. maculosus* Cuv. and Val. (*lunulatus*, *apua*, and *catus* of authors); *Promicrops itaiara* (Lichtenstein), instead of *P. guttatus.*

Dr. Günther shows that in forming his complex *Perca guttata*, Linnæus had a specimen in hand from which his color notes were drawn. Excluding erroneous synonyms, this specimen may be regarded as the typical *P. guttata.* Dr. Günther notes that *Stellifer lanceolatus* has the downward directed spine of the subgenus Zestidium. He, however, wrongly identifies it with the type of the latter group, *S. illecebrosus*, from Panama. The two species differ notably in numbers of fin rays and gill rakers.

Besides these specimens, we may note that Dr. Einar Lönnberg has given a supplementary account of the Linnæan fishes in the University of Upsala. The original type of *Exocœtus volitans* is the flying fish called *Halocypselus evolans*, as indeed the description indicates. Exocœtus is therefore the right name for the group of flying fishes having short ventrals, the Halocypselus of Weinland, while the name Cypselurus of Swainson is revived for the large flying fishes.

D. S. J.

Meek on the Fishes of Lake Muskoka. — In the publications of the Field Columbian Museum of Chicago, Dr. Seth E. Meek has notes on the fishes of Lake Muskoka at Gravenhurst, Ontario. One

new species, *Notropis muskoka*, is described. This species is of the subgenus Chriope, an ally of *N. cayuga*. *Etheostoma boreale*, described by Jordan from Montreal in 1884, and not since seen, has been rediscovered by Dr. Meek in Gull Lake, near Lake Muskoka. D. S. J.

Function of Vascular Ampullæ in Composite Tunicates. — The colonial blood vessels of the composite tunicates belonging to the family Botryllidæ often show a considerable number of terminal enlargements — the ampullæ. These are found almost anywhere within the colony, but are especially numerous along its edges. They have been regarded without much reason as developing zoöids, an opinion generally abandoned for several more recent views; namely, that they are reservoirs for blood, organs for the excretion of the test matrix, or for respiration. Dr. F. W. Bancroft[1] has shown that they normally execute coördinated pulsations, which continue, with some change in the coördination, after separation from the rest of the colony. The rhythm of the ampullar pulsations is not affected by the reversals of the hearts in the zoöids. The pulsations are very slow, and the contractile tissue seems to be a thin layer of pavement epithelium. Such coördination as the ampullæ show is brought about principally by blood pressure. In an æstivating colony of *Botrylloides gascoi*, the circulation was kept up almost entirely by the ampullæ. They must, therefore, be regarded as organs for the propulsion of the blood. G. H. P.

Sense Cells in the Integument of Worms. — L. Atherton[2] has made a study of the integument of the fresh-water worm Tubifex, with special reference to its nervous structures. The epidermis, beneath which there is no basement membrane, is usually a single layer of cells, produced apparently from the growing zone at the caudal end of the worm. Sensory cells of a spindle shape, or more swollen, occur isolated, in loose groups, or as well-defined clusters; externally they are provided with sensory bristles, and internally they give rise to nerve fibres, which extend to the central nervous organs. Isolated sensory cells are numerous over the caudal end, sparse over the middle trunk region, and numerous again over the anterior part, where they may bear more than a single sensory bristle. Loose

[1] Bancroft, F. W. A New Function of the Vascular Ampullæ in the Botryllidæ, *Zool. Anzeiger*, Bd. xxii, pp. 450–462.

[2] Atherton, L. The Epidermis of Tubifex rivulorum Lamarck, with Especial Reference to its Nervous Structures, *Anat. Anzeiger*, Bd. xvi, pp. 497–509.

groups of sensory cells are found on all regions of the body except the anterior end. Well-defined clusters are found only on the prostomium and first few segments.

G. H. P.

The Eyes of the Polyphemidæ. — The eyes of the family of minute crustaceans, the Polyphemidæ, have been the subject of careful investigation by Dr. O. Miltz.[1] The eyes are compound, and each retinal element or ommatidium is composed of two distal cells, forming part of the corneal hypodermis, of five cells forming the cone, of two supporting cells, and of a group of five retinular cells. The nerve fibres pass centrally from the retinular cells. The development, physiology, and biological significance of the eyes are considered.

G. H. P.

Zoölogical Notes. — An Uncinaria from a panther that died in the Königsberg Zoo has furnished Cohn (*Arch. de Parasitol.*, Vol. II, No. 1, pp. 5–22, 1899) with some important data on the life history of these forms and the injuries they produce. An introductory discussion clears up the synonymy and shows that three good species occur in the Felidæ. The form studied, *U. perniciosa*, was found abundantly in small, dark-colored nodules in the wall of the small intestine, each nodule containing a number of individuals, among which the females were more numerous. A histological study of these nodules showed that they always lay in the submucosa, which was enormously thickened at that point at the expense of the circular muscle layer, and that each opened into the intestinal lumen by a small pore at which the epithelium was inturned. Larvæ much like those of *U. duodenalis*, recently described by Looss, were numerous in the intestinal mucus, and a single older form was met between the villi. In the nodules, on the other hand, only sexually mature individuals were found, together with the eggs. Cohn outlines the life history as follows: There is no secondary host, but the larvæ are brought directly into the intestine of the primary host, and when they have reached a certain period of growth they invade the wall of the canal and cause there the growth of nodules. The results of other investigators are interpreted in the light of this work which conforms, moreover, to the conjecture of Railliet in the case of *Sclerostoma equinum*.

[1] Miltz, O. Das Auge der Polyphemiden, *Zoologica*, Bd. xi (1899), Lieferung 4, pp. 1–60, Taf. I–IV.

A new pelagic nemertine is described by Woodworth (*Bull. Mus. Comp. Zoöl.*, Vol. XXXV, No. 1, July, 1899). It was taken by the *Albatross* while trawling at a depth of 500 to 2000 fathoms in the Pacific Ocean, and differs from the forms obtained by the *Challenger* expedition in several important particulars which justify its inclusion in a new genus — Planktonemertes.

Metagenesis in the Coccidia and Hæmosporidia is the subject of a recent important résumé by Schaudinn (*Zool. Centralblatt*, Vol. VI, No. 22, pp. 765–783, October, 1899). The article is accompanied by an extensive bibliography of the subject.

Notes on some exotic species of ectoparasitic trematodes, recently published by S. Goto (*Journ. Sci. Coll. Imp. Univ.*, Tokyo, Japan, Vol. XII, No. 4, pp. 263–295, Pls. XX, XXI, 1899), include studies made in this country, chiefly at the Newport Marine Laboratory. A dozen species, seven of which are new, are described with care, numerous points in the synonymy cleared up, and many details of anatomical structure worked out. One new genus, Dionchus, was discovered which unites characters of the Gyrodactylidæ and Monocotylidæ. American students are fortunate in having such satisfactory descriptions and illustrations of native forms as those given here.

C. T. Simpson has given in the *Bulletin of the United States Fish Commission* for 1898 a readable and interesting account of the structure, habits, enemies, and commercial value of our fresh-water mussels.

No. 5 of the third volume of the *American Journal of Physiology* contains the following articles: "A Modified Soxhlet Apparatus for the Extraction of Fat from Liquids," by A. E. Taylor; "A New Form of Piston Recorder and Some of the Changes of the Volume of the Finger which it Records," by W. P. Lombard and W. B. Pillsbury; and "Secondary Rhythms of the Normal Human Heart," by W. P. Lombard and W. B. Pillsbury.

The first number of the *Biological Bulletin*, edited by the director and members of the staff of the Marine Biological Laboratory at Woods Holl, Mass., has appeared, and contains the following articles: "Some Relations between Nervous Tissue and Glandular Tissue in the Tunicata," by M. M. Metcalf; "Regeneration of Tissue composed of Parts of Two Species," by T. H. Morgan; "Dinophilus gardineri

(sp. nov.)," by A. Moore; "Some Muscinæ of North America," by G. de N. Hough; and "Experimental Studies upon Hydromedusæ," by C. W. Hargitt. Under the head of "Bibliography and Publication" is printed the second report of the English committee on these subjects.

BOTANY.

The Last Contribution from the U. S. National Herbarium[1] is one of the largest and best of this valuable series. It is chiefly written by Dr. J. N. Rose, and is largely devoted to the Mexican flora. The more noteworthy features are: (1) a proposed rearrangement of the suborder Agaveæ, in which eight genera are recognized, Manfreda is kept distinct from Agave, Bravoa is reduced to Polianthes, and a new genus, Pseudobravoa, is established; (2) a synopsis of the small but difficult leguminous genus Nissolia, in which thirteen species are recognized and figured; (3) partial keys to the Mexican and Central American species of Zanthoxylum, Turnera, and Clitoria; (4) a considerable series of critical notes on the Malvaceæ, in which *Anoda incarnata* H. B. K. and a nearly related new species are united in the reëstablished and undoubtedly valid genus Periptera; (5) a synopsis of the species of Waltheria and Cedrela ranging north of the Isthmus of Panama; (6) a key to the Mexican and Central American species of Thalictrum; (7) the characterization of many new and capitally illustrated Mexican species of various orders; (8) the description of Treleasea, a new genus of Commelynaceæ, with three species ranging from Texas southward into Mexico; (9) notes on useful plants of Mexico.

The last subject is treated under the following heads: cereals and vegetables, fruits, beverage plants, seasoning and flavoring plants, medicinal plants, soap plants, tanning and dye plants, fibre plants, brush and broom plants, fence and hedge plants. The illustrations, chiefly half-tones, are numerous, clear, and well chosen.

Regarding the systematic part of Dr. Rose's work, it may be said that it bears internal evidence of great care and good judgment. The copious and painstaking citation of literature and synonymy testifies to the excellence of the present bibliographical methods in the botanical work of the department of agriculture under Mr. Coville's direction. The economic portions of the paper have

[1] Vol. v, No. 4, pp. 145–259, t. 18–64; issued Oct. 31, 1899.

unusual merit from the fact that the plants yielding the useful products are not named in the vague way too frequent in such discussions, but have been subjected to the critical identification of a systematic expert.

Besides the above-mentioned papers by Dr. Rose, the contribution contains a short article by Prof. L. F. Henderson, characterizing two new plants from Idaho, and another by Professor Coulter and Dr. Rose, describing and figuring an interesting new umbelliferous genus, Hesperogenia, from Mt. Rainier.

B. L. R.

Bailey's Botanizing.[1] — Under the title of *Botanizing*, Professor Bailey of Brown University has issued a revised and enlarged edition of *The Botanical Collector's Handbook*. Few of the methods taught are likely to lead to measurably poor results, though experience will teach profitable modifications of some of them to any boy with Yankee ideas, and most of the suggestions are likely to be worth many times the cost of the book to a beginner.

T.

Botanical Notes. — Important recent papers on seed anatomy are: Pammel, "The Histology of the Caryopsis and Endosperm of Some Grasses" (*Transactions Acad. Sci. of St. Louis*, VIII, No. 11); Pammel, "Anatomical Characters of the Seeds of Leguminosæ, chiefly Genera of Gray's *Manual*" (*loc. cit.*, IX, No. 6); and Schlotterbeck, "Developmental History of Important Seeds. The Anatomy of the Cotton Seed and the Development of its Seed Coats" (*Pharmaceutical Archives*, II, No. 11).

A catalogue of the spontaneous hybrids of the European flora, by E. G. Camus, is being published in current numbers of the *Journal de Botanique*.

The most important recent publication on American fossil plants is Professor Ward's "Cretaceous Formation of the Black Hills as indicated by the Fossil Plants," extracted from the *Nineteenth Report of the United States Geological Survey*. The paper is profusely illustrated, largely by reproductions of photographs made directly from the specimens.

In the advance sheets for December 19 of *Consular Reports*, Edward H. Thompson, United States Consul at Progreso, gives some interesting information concerning sisal fibre, from which it

[1] Bailey, W. W. *Botanizing*. A guide to field collecting and herbarium work. Providence, Preston & Rounds Co., 1899.

appears that the fibre of this Yucatan agave was first brought into considerable use between 1750 and 1780, though the first plantation was not established until 1848. The largest plantation to-day is said to be yielding about 375,000 pounds of cleaned fibre per month.

The Amoles, or saponifying plants, of Mexico are treated in Vol. III of *La Naturaleza*, by Dr. Manuel Urbina.

Mr. Gifford Pinchot, Forester of the United States Department of Agriculture, has published the first part of a primer of forestry as *Bulletin 24* of his Division. The book is clear, simple, well illustrated, and attractively gotten up.

Robert T. Hill's notes on the forest conditions of Porto Rico are published as *Bulletin 25* of the Division of Forestry of the Department of Agriculture. A number of photogravures illustrate the graining of the principal Porto Rican woods.

Persons who go to the Adirondacks will find useful a recently issued flora of North Elba, by Professor Peck. It is published as No. 28 of Vol. VI of the *Bulletin* of the New York State Museum, and may be bought for twenty cents.

A comparison of the floras of the alpine and temperate regions on the great Mexican volcanoes is published by Professor Heilprin in Vol. III of the Mexican journal *La Naturaleza*.

An interesting list of plants growing upon trees at Bad Nauheim, classified according to their means of dissemination, by Jaap, is to be found in the September–October number of the *Deutsche botanische Monatsschrift*.

Icones Selectæ Horti Thenensis is the title of a new serial, devoted to the plants flowering in the extensive collections of M. van der Bossche at Tirlemont, Belgium. The plates are drawn by D'Apreval, and accompanied by text by de Wildeman. The first fascicle appeared in September, 1899.

Draba, as represented in the West by the aurea stylosa forms, is analyzed by Heller in the December *Bulletin* of the Torrey Club, with the result that three species and one variety are described as new.

Some of the Canadian violets recently split off from what has passed current for *Viola cucullata*, are brought together by J. M. Dickson in the *Journal and Proceedings of the Hamilton Association for 1898–99*.

A chart showing the blossoming season of the wild-goose plum in 1898, published in *Farmers' Bulletin 103* of the Department of Agriculture, will be of interest to students of phenology.

Ten additional species of Sisyrinchium from the Southern States are described by Bicknell in the *Bulletin* of the Torrey Club for December.

Captain John Donnell Smith has recently distributed the fifth volume of his *Enumeratio Plantarum Guatemalensium*, etc., to which are appended, as heretofore, extra-prints of his later articles published in the *Botanical Gazette* descriptive of plants of this region.

The results of a biological survey of Mt. Shasta, California, are published by Dr. Merriam as No. 16 of *North American Fauna.* Though avowedly incomplete, his notes on the distribution of Shasta plants are of unusual value because of the detailed data given under each entry.

A catalogue of the ferns and flowering plants of South Dakota, by Professor Saunders, constitutes *Bulletin* 64 of the Agricultural Experiment Station of that state.

The second fascicle of *Icones Bogorienses*, published by the Buitenzorg Garden, deals with the Anonaceæ of that establishment, and is written by Dr. Boerlage.

Apropos of recent attempts to classify the species of Rosa on anatomical grounds, M. Crépin publishes some valuable generalizations in the thirty-seventh volume of the *Bulletin* of the Royal Botanic Society of Belgium.

A study of the Japanese lacquer tree, *Rhus vernicifera*, from the standpoint of morphology and anatomy, is reprinted by Dr. Möbius from the *Abhandlungen* of the Senckenbergische naturforschende Gesellschaft.

A very curiously fasciated plant of an unnamed species of Cotyledon is described and figured in a teratological paper by Gallardo in No. 4 of the *Comunicaciones* of the Buenos Aires Museo Nacional, recently issued.

Students of hybrid docks will be interested in a paper on the North European forms of the genus Rumex, by Murbeck, reprinted from *Botaniske Notiser* for 1899.

Professor V. M. Spalding's paper on the white pine (*Pinus strobus*), revised and enlarged by Professor Fernow, is published as *Bulletin* 22 of the United States Department of Agriculture.

A revision of the North American species of the genus Frullania, by Professor A. W. Evans, is published in Vol. X of the *Transactions* of the Connecticut Academy of Arts and Sciences.

Professor Macbride has done a useful piece of work in allowing his *Myxomycetes of Eastern Iowa* to expand into the handsome volume, *The North American Slime-Moulds*, just issued by The Macmillan Company — a volume which should be in every botanical library.

Students of kephir and similar ferments will find interest in a paper by H. Marshall Ward and J. Reynolds Green, on a sugar bacterium, reprinted from Vol. LXIV of the *Proceedings* of the Royal Society.

The October number of the *Queensland Agricultural Journal* contains a report on the timber trees of a district of North Queensland, by J. F. Bailey, which includes an annotated list of 111 species, several of which are figured.

"Forestry Notes for Iowa" is the title of a paper by Professor Macbride separately printed in advance from the tenth *Report* of the Iowa Geological Survey.

A preliminary catalogue of plants poisonous to stock, by V. K. Chesnut, is reprinted from the annual *Report* of the National Bureau of Animal Industry, for 1898.

The *Bulletin* of the Torrey Botanical Club for November contains papers on *Lycopodium complanatum* and *L. chamæcyparissus*, by F. E. Lloyd; the dichotomous Panicums, by G. V. Nash; *Delphinium carolinianum* and related species, by P. A. Rydberg; New and interesting plants from western North America, by A. A. Heller; A new genus of powdery mildews — Erysiphopsis, by B. D. Halsted; and The habitats of the Pellæas, by E. J. Hill.

Part I of the second volume of the *Contributions* from the botanical laboratory of the University of Pennsylvania contains nine papers, presenting the results of laboratory investigation in various fields of botany.

In 1879 Professor Beal buried seeds of twenty-two species of plants in the soil, in inverted bottles, and at the end of each period

of five years the viability of some of them has been tested. After twenty years in the soil, nine species, all common weeds, germinated, the percentage varying from 2 to 58, while thirteen species failed to grow, — as appears from a note in the September number of the *Journal* of the Columbus Horticultural Society.

From a recent article in *Gartenflora* it appears that at the great St. Petersburg botanical garden 24,176 species and varieties of plants are cultivated, the herbarium contains over a million and a half specimens, and the library consists of 14,040 works, bound in 27,588 volumes.

PALEONTOLOGY.

The Later Extinct Floras of North America.[1] — In the preface Dr. Hollick explains the conditions under which this posthumous work of Professor Newberry's was prepared for the press. An edition of twenty-five plates was issued without text in 1878, under the title, *Illustrations of Cretaceous and Tertiary Plants of the Western Territories of the United States.* Subsequently a revised edition of these, with forty-three additional plates, was printed, but not distributed, being withheld for the completion of the text. Professor Newberry's death stopped further progress on the work. Two sets of the plates bore manuscript names. From these plates, Professor Newberry's manuscript, the labels on type specimens, and Professor Newberry's previous publications, the present text was compiled. This was evidently a laborious undertaking carefully carried out, as evinced by the text and occasional editorial notes.

One hundred and seventy-four species are figured and are described in the text, with the exception of some species of which the editor found no manuscript or other descriptions by Professor Newberry. The plates are beautifully executed. The species described are all from the Cretaceous and Tertiary formations, and are from the Western States and Territories, excepting *Sequoia gracillima*, described as also from New Jersey, and *Salix membranacea*, described from New Jersey only. Six new species are described, namely, *Abietites cretacea*, *Sabal grandifolia*, *Myrica* (?) *trifoliata*, *Salix foliosa*,

[1] Newberry, John Strong. *The Later Extinct Floras of North America*, a posthumous work, edited by Arthur Hollick. Monograph of the U. S. Geological Survey, vol. xxxv, pp. i–xvii, 1–295, Pls. I–LXVIII. Washington, 1898.

Alnus serrulata fossilis, and *Magnolia elliptica*. A few new names or new combinations occur due to the necessities of nomenclature or corrections in generic reference. Many of Professor Newberry's species are figured for the first time. An important feature is the figures of several specimens which are the originals of tracings sent to Professor Heer, and from which that author published new species. These are *Populus litigiosa*, *Leguminosites marcouanus*, *Sapotacites haydenii*, and *Phyllites obcordatus*. In a table is given a list of localities from which specimens came as mentioned in the text.

It is most desirable in publication to state in what museums specimens described are located, and the absence of such information in this volume is an unfortunate omission. The undesirable tendency to consider species as distinct, simply because they occur in different geological horizons, is shown in several places, as under *Salix meekii* Newberry, of the Dakota Group, Cretaceous, where the author says that this species has a resemblance to several Tertiary species, ". . . from which it might be unwise to regard it as distinct if they were from the same formation." Similarly it is undesirable to give a separate name to fossils when their characters are so close to living forms that they are systematically indistinguishable. Cases in which this is done are *Onoclea sensibilis fossilis*, *Corylus rostrata fossilis*, *Alnus serrulata fossilis*. The description of fossil forms "indistinguishable" from living forms, as stated in several cases, raises an objection to the title of the volume, *The Later Extinct Floras of North America*. Species of fossil plants, as of fossil animals, should be based on the characters they present, independently of how long they may have lived, as represented by the lapse of geological time.

R. T. J.

Coal Measure Plants.[1] — In the course of publications by Williamson, Scott, Seward, and others, frequent reference has been made to the Binney collection of fossil plants which was presented to the Woodwardian Museum at Cambridge, England, in 1892. Although some of the species have been repeatedly investigated during the last few decades, the collection embraces other species which illustrate important morphological points hitherto overlooked, and thus afford valuable evidence of a phylogenetic character. Mr. Seward has undertaken to indicate the nature of the data he has gathered from the collection, and thereby places in the hands of working paleo-

[1] Seward, A. C. Notes on the Binney Collection of Coal Measure Plants, *Proc. Cambridge Phil. Soc.*, vol. x, iii, pp. 137.

botanists a number of very essential facts. The present "Notes" deal with four specimens of *Lepidodendron harcourtii* and *Halonia regularis*, which the author regards as specifically identical; and with a new genus of Cycadofilices to which he assigns the name of Megaloxylon, as represented by a single species, *M. scottii.*

D. P. P.

Matonia pectinata.[1] — In an important contribution to the *Philosophical Transactions of the Royal Society*, which gives evidence of the most searching care, Mr. Seward selects Matonia as representing an isolated type of ferns requiring further examination anatomically, in order to determine its relations to the Cyatheaceæ and Gleicheniaceæ, toward which it has been customary to assign it an intermediate position. Mr. Seward concludes that while the genus must hold an independent position among ferns, its affinities are most nearly with those of the Cyatheaceæ. His studies of existing species are designed to have a direct bearing upon the geological history of the Matonineæ, and he therefore brings into comparison Laccopteris and Matonidium in particular; from all of which he concludes that Matonia represents the survival of a family of ferns now confined to a few localities in Borneo and the Malay Peninsula, and represented by two living species, which in Mesozoic time had a wide geographical range, being especially abundant in the European area during the Jurassic and Lower Cretaceous times. The apparent absence of the Matonineæ from Tertiary formations suggests that these forms reached their maximum development in the Mesozoic, and that toward the close of the Cretaceous a decided restriction in geographical range had developed.

D. P. P.

Medullosa anglica.[2] — Dr. Scott's important contributions to our knowledge of the Cycadofilices have been recently enlarged by the description of a new species of Medullosa to which he assigns the name of *M. anglica.* He points to the fact that several genera such as Nœggerathia, Medullosa, Cladoxylon, Lyginodendron, Heterangium, and Protopytis are now to be grouped under Potonie's con-

[1] Seward, A. C. The Structure and Affinities of Matonia pectinata, R. Br., with Notes on the Geological History of the Matonineæ, *Phil. Trans. Roy. Soc.*, Ser. B, vol. cxci (1899), pp. 171.

[2] Scott, D. H. On the Structure and Affinities of Fossil Plants from the Palæozoic Rocks. III. Medullosa anglica, a new representative of the Cycadofilices, *Phil. Trans. Roy. Soc.*, Ser. B, vol. cxci (1899), pp. 81.

venient name of Cycadofilices; and also to the very important correlation of structures hitherto regarded as representing distinct organisms, but now known to be different members of plants belonging to the genus Medullosa.

The specimens of *M. anglica* studied were obtained from the colliery at Hough Hill, Stalybridge, and are of exceptional interest, not only as "being the first recorded British specimens of the genus," but "also from their geological horizon, which is considerably more ancient than that of the continental Medulloseæ." They are at the same time the most complete examples of the genus hitherto studied, and they thus furnish most important data with respect to our knowledge of the entire group. Although lacking in some of the most important structural characters (the fructification), the material furnishes further and important additions to our knowledge of the filicoid origin of the cycads.

D. P. P.

NEWS.

We learn that the Zoölogical Society of Holland is preparing a series of synopses of the fauna of Holland, following somewhat after the style of the Keys now being published in this journal.

The *Plant World*, hitherto published by Willard Clute & Co. of Binghamton, N. Y., will be issued in future by the Plant World Co., Washington, D. C.

Dr. Elliott Coues, the well-known ornithologist and for some years an associate editor of the *American Naturalist*, died in Baltimore, December 25. He was born in Portsmouth, N. H., Sept. 9, 1842, was graduated in arts and medicine from the Columbian University at Washington, and served as assistant surgeon in the U. S. Army from 1862 to 1881. He taught anatomy and zoölogy in Norwich University, Columbian University, and the Virginia Agricultural College. He was best known for his works on birds, including his *Keys to North American Birds* (three editions), *Birds of the Colorado Valley*, *Birds of the Northwest*, *Ornithological Biography*, etc., in which are to be found some of the best sketches in the language. He also worked on mammals. During his later years he became enamored with theosophy and neglected scientific work.

Appointments: E. A. N. Arber, demonstrator in paleobotany in the University of Cambridge. — Dr. F. W. Bancroft, instructor in physiology in the University of California. — Dr. Edmond William Wace Carlier, professor of physiology in Mason College, Birmingham, England. — Dr. Dandler, privat docent for anatomy in the University of Vienna. — W. H. L. Duckworth, instructor in physical anthropology in the University of Cambridge. — Grafton Elliott-Smith, demonstrator of anatomy in the University of Cambridge. — Dr. Otto von Furth, privat docent for physiology in the University of Vienna. — Dr. Martin Heidenhain, professor extraordinary of anatomy in the University of Tübingen. — Dr. J. J. Jahn of Vienna, professor extraordinary of geology in the newly established technical school at Brünn, Austria. — Alfred Jentzsch, geologist at the Geological Landesanstalt in Berlin. — S. J. Korshinsky, director of the herbarium of the Academy of St. Petersburg. — Dr. Alfred Krolopp, assistant

professor of botany in the Agricultural School at Altenburg. — W. Leslie, director of the botanical gardens in Trinidad. — Mr. Loye H. Miller, professor of chemistry and natural history in Oahu College, Honolulu, Hawaiian Islands. — Dr. Thomas H. Montgomery, Jr., assistant professor of zoölogy in the University of Pennsylvania. — Dr. Erik Gottlieb Müller, professor of anatomy in the Karolinian Institute at Stockholm. — Dr. Bohumil Nemesch, privat docent for plant anatomy and physiology in the Bohemian University at Prag. — James Louis North, keeper of the Museum of the Royal Botanical Society in London. — Professor Edward Orton, state geologist of Ohio, in succession to his father, the late Edward Orton. — Professor Picart of Bordeaux, professor of anatomy in the University at Lille, France. — Dr. Gustav Piotrowski, professor extraordinary of physiology in the Veterinary School at Lemberg. — Dr. Mat. Semper, privat docent for anatomy in the Technical School at Aachen. — Dr. E. O. Sisson, director of the histological laboratory at Keokuk, Iowa. — Dr. Velich, privat docent for animal physiology and pathology in the Bohemian University at Prag. — Nikolaus Warpachowsky of St. Petersburg, director of fisheries for the district of Archangel. — Dr. Wedekind, privat docent for natural science in the University of Tübingen.

Deaths: Dr. Christian Brügger, naturalist and director of the museum in Chur, Switzerland, in October, aged 66. — Dr. Deike, paleontologist, in Mülheim. — Professor Theodor Ebert, geologist of the Geological Landesanstalt in Berlin, in September, aged 42. — Nikolaus W. Grigorjeff, a young phytopaleontologist in the government of Charkoff, Russia, drowned July 16. — Dr. Ragnar Hult, botanist, and docent in geography in the University of Helsingfors, September 25, aged 42. — Dr. Matts Adolf Lindblad, formerly docent for botany in the University of Upsala, June 30, aged 78. — Hippolyte Lucas, assistant in entomology in the Paris Museum, September 29. — Dr. Josef Majer, formerly professor of anatomy in the University of Cracow, July 3, aged 91. — Dr. Geza von Mihálovics, professor of anatomy and embryology in the University of Budapesth, aged 55. — Michael Iwan Pylajeff, a Russian mineralogist, Feb. 3, 1899, aged 57. — Georg Ruscheweyh, lepidopterologist in Buenos Aires, August 2, aged 72. — George, Baron Schilling von Canstatt, ornithologist, in Scutari, Albania. — Dr. Adolf Schmidt, diatom student, in Aschersleben, Germany. — Christian Schwemmer, botanist, at Nürnberg. — Dr. Arthur Cowell Stark, ornithologist,

killed by a shell, November 18, at Ladysmith, South Africa. — Siegfried Stauffer, founder of the natural history museum in Luzern, August 3. — Samuel Stevens, entomologist and formerly a large natural history dealer in London, August 29, aged 82. — Friedrich Stolz, student of cryptogamic botany, killed by a fall in the Tyrol, August 14, aged 21. — Dr. Carl Gustav Thompson, student of Hymenoptera and custodian of the entomological collections at Lund, Sweden, in September, aged 72. — Dr. Stephen Baron von Washington, ornithologist, at Pols, Styria, September 9, aged 41. — Rev. William Farren White, entomologist, at Bournemouth, England, July 21, aged 65. — George Buchanan Wollaston, student of ferns, at Clapham, England, March 26, aged 85. — Frederik Mauritz van der Wulp, student of the Diptera, at The Hague, aged 80. — Professor R. Yatube, botanist, in Japan. — John Bridgman, English entomologist, October 6, aged 63.

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CONTENTS

PAGE

I. **The Angulation of the Limbs of Proboscidia, Dinocerata, and other Quadrupeds in Adaptation to Weight** . HENRY FAIRFIELD OSBORN 89

II. **The Specific Gravity of Some Fresh-Water Animals in Relation to their Habits, Development, and Composition** STEPHEN R. WILLIAMS 95

III. **The Mosaic of Single and Twin Cones in the Retina of Fishes** CARL H. EIGENMANN and GEORGE DANIEL SHAFER 109

IV. **Note on the Genital Organs of Zaitha** THOMAS H. MONTGOMERY, JR. 119

V. **Willey on the Enteropneusta** . . . . . MAYNARD M. METCALF 123

VI. **Synopses of North-American Invertebrates. VII. The Cyclometopous or Cancroid Crabs of North America** . MARY J. RATHBUN 131

VII. **Reviews of Recent Literature:** *Anthropology,* Anthropological Notes — 145
General Biology, A Study of Heredity among the Deaf, Blatchley's 146
Gleanings from Nature — *Zoölogy,* Artificial Production of Rhythmic 150
Muscle Contractions, Evermann and Marsh on Fishes of Puerto Rico, Tunicates of Pribilof Islands, Physiology of the Cephalopods, Excretion in Mollusca, The Heart of Anodonta, Grafting and Regeneration in Hydromedusæ, Regeneration in Grafted Tissue, Note — *Geology,* The 156
Absaroka Range of the Rocky Mountains — *Petrography,* Experimental 160
Petrography, Notes

VIII. **Publications Received** 163

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Vol. XXXIV. *February, 1900.* No. 398.

THE ANGULATION OF THE LIMBS OF PROBOSCIDIA, DINOCERATA, AND OTHER QUADRUPEDS, IN ADAPTATION TO WEIGHT.

HENRY FAIRFIELD OSBORN.

With material which in most cases belongs to several individuals the reconstruction of an extinct animal requires the greatest care and skill. When the proportions are determined the work is merely begun, for delicate calculation is needed to give the spine its proper curvature, to place the head in its true position, and then to give the bones of the fore and hind limbs their natural angles with each other. The angulation is most important because it finally determines the elevation of the body of the animal above the ground. Few of the mounted skeletons in our museums have the limbs correctly placed, and the drawings of skeletons, even in the best works, are often at fault in this respect.

Professor Marsh's statement in his monograph upon the Dinocerata, that in my restoration of Loxolophodon published in 1881, "the bones of the fore limb are in a position impossible in life," led me some years ago to study the means of

ascertaining the position and angulation of the limbs in fossil quadrupeds, and especially of the fore limb. Professor Marsh's criticism refers to the fact that, in the restoration referred to, the humerus is only slightly bent backwards, and this does not indicate sufficient flexure at the elbow.

In cases of this kind our material for study lies in the articular surfaces of the fossil limb bones and a comparison of these surfaces with those in the nearest allied living types. My ground for restoring the limbs of Loxolophodon was the close likeness which exists between the articular surfaces and shafts of the humerus and radius and ulna of this type and those of the elephant.

In order to test the force of Professor Marsh's criticism and to guard

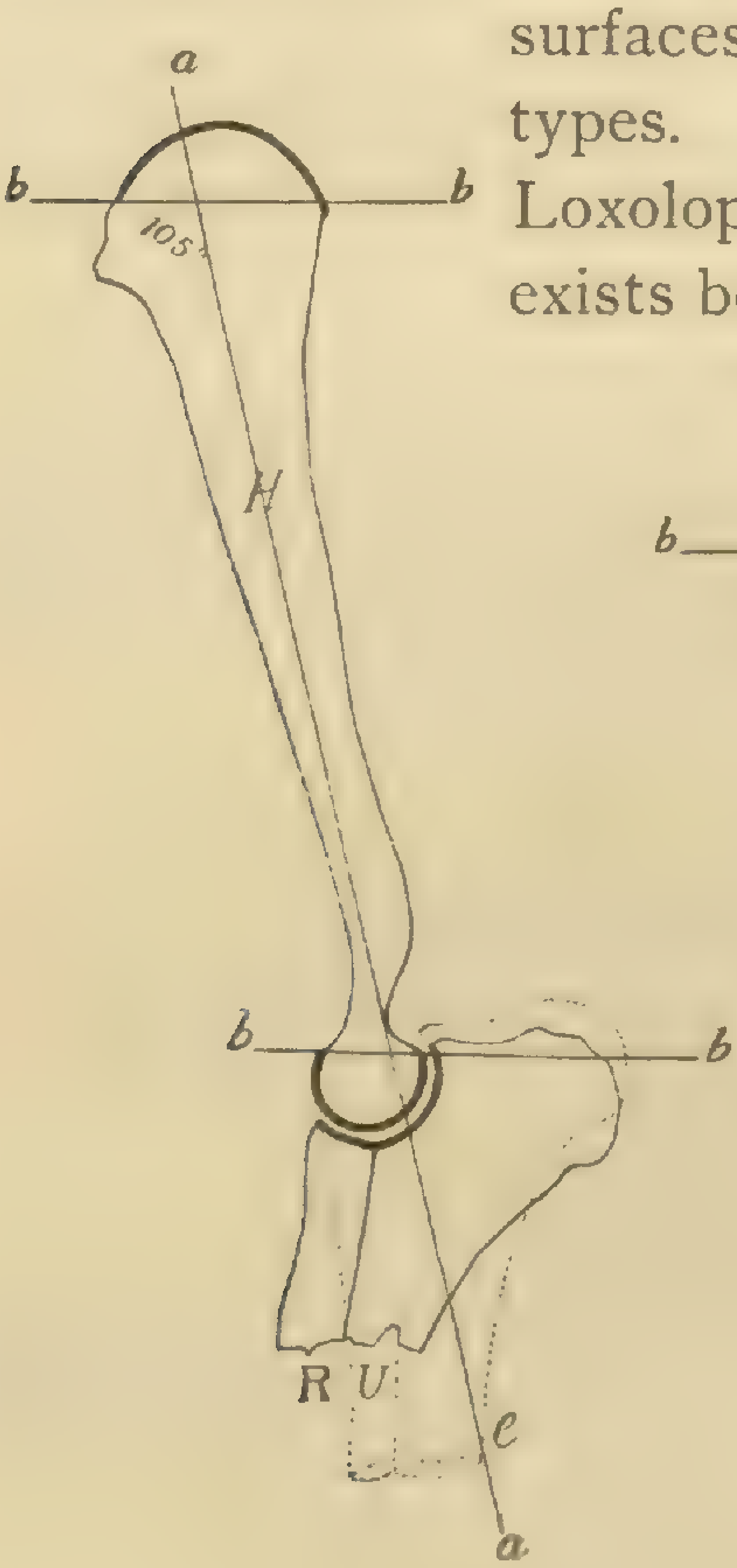

FIG. 1.

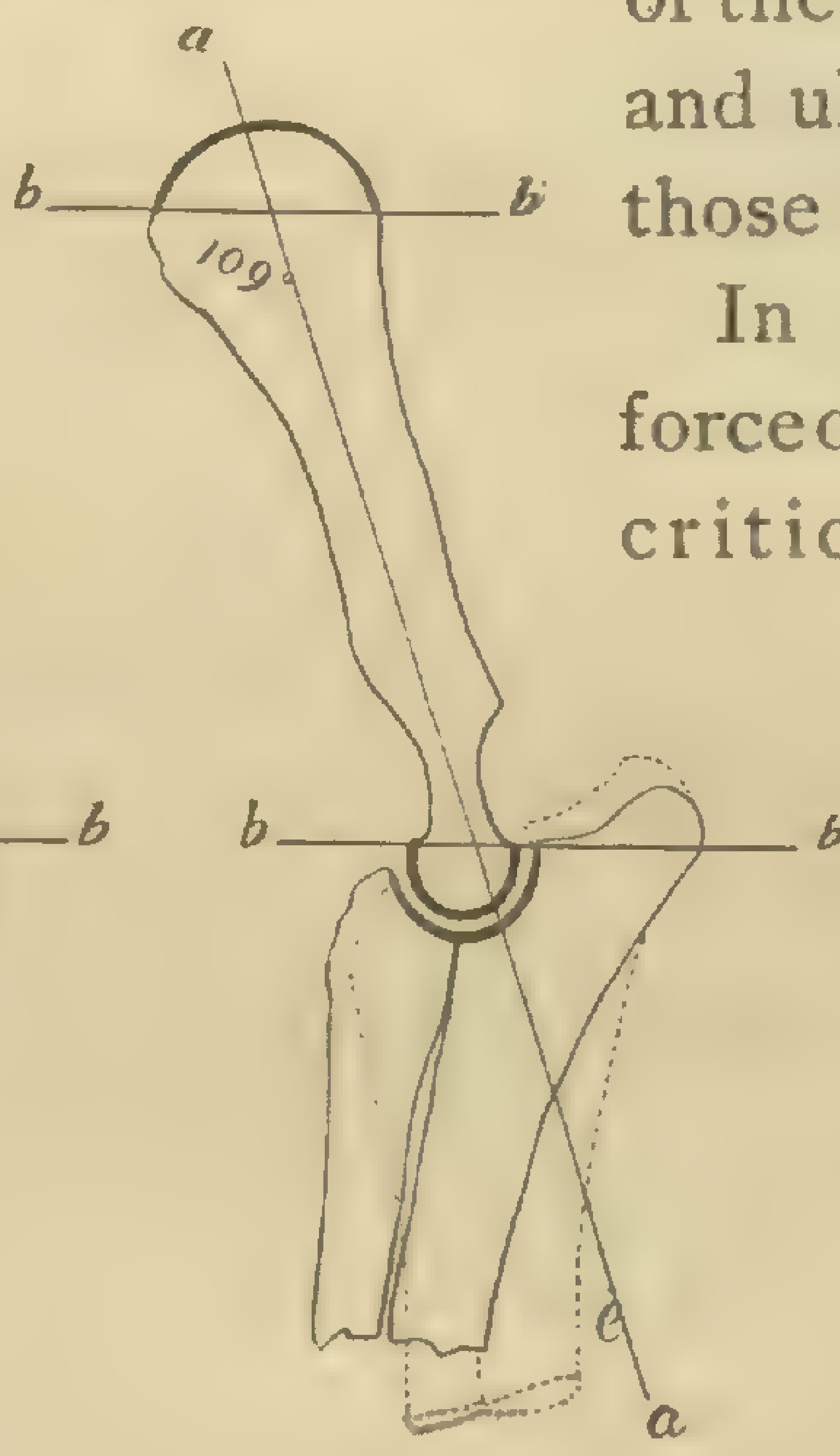

FIG. 2.

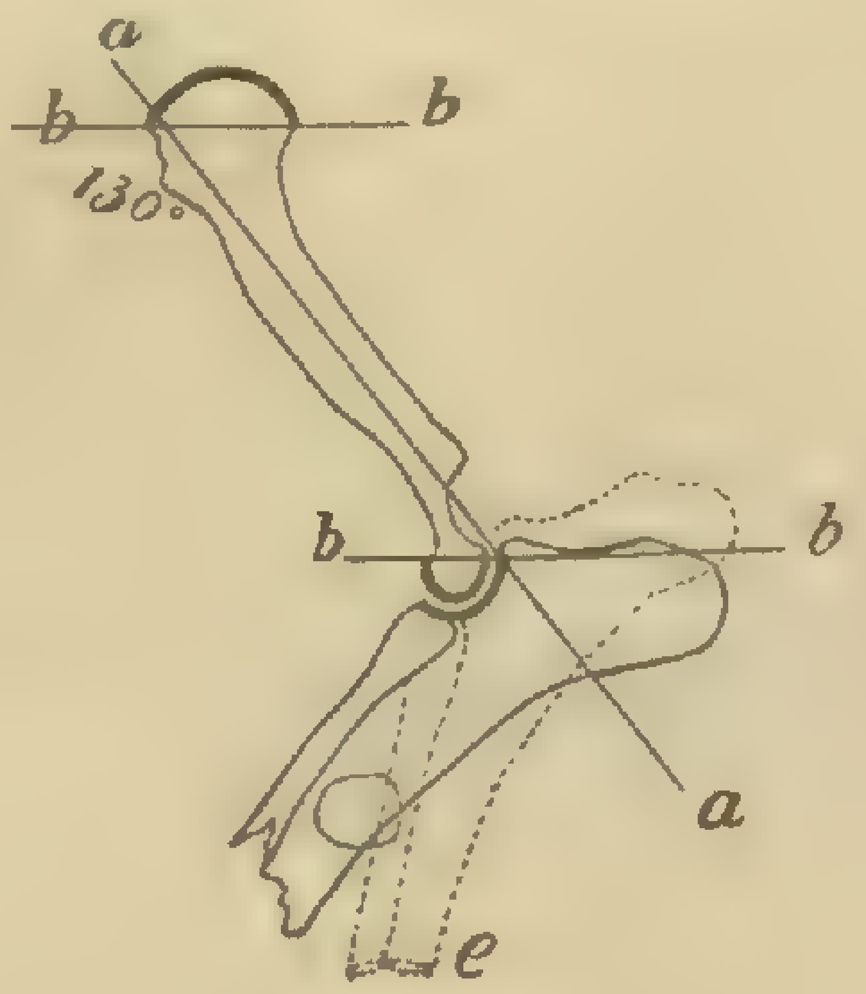

FIG. 3.

ANGULATION OF FORE LIMB.

FIG. 1. — *Elephas indicus*, longitudinal section of humerus, ulna and radius.
FIG. 2. — *Uintatherium cornutum*, longitudinal section of humerus, ulna and radius.
FIG. 3. — *Rhinoceros unicornis*, longitudinal section of humerus, ulna and radius.

against what might be a misleading resemblance, full-sized vertical sections were made of the fore limbs of *Uintatherium* (*Loxolophodon*) *cornutum* and of *Elephas indicus* in the Princeton collection. A section of a rhinoceros fore limb was also made for comparison. These were reduced by photography to a scale of 1 in 18 and are copied in Figs. 1, 2, and 3.

In each humerus a line (*a–a*) is drawn through the central axis of the shaft and two lines (*b–b*) are drawn through the

anterior and posterior intersecting edges of the proximal and distal articular surfaces or facets.

Several facts are at once brought out by these sections which bear upon the arthrology of the Ungulate limb.

(1) As the humerus, in the descent from the primitive bent-limbed types, is directly more vertically forwards, the articular facets are tilted from an oblique angle to more nearly a right angle with the shaft.

(2) At the same time the proximal or scapular facet shifts forwards, while the distal or ulno-radial facet shifts backwards

FIG. 4. — Mother elephant "Hebe" and baby "Americus," showing the excessive straightening or over extension of the fore limb. (By permission, from a copyrighted photograph by Schreiber & Sons, Philadelphia.)

upon the shaft's axis. An extreme instance of such shifting is shown in the transition from the rhinoceros (Fig. 3) to the elephant type (Fig. 1).

(3) The proximal and distal articular facets shift uniformly, and their edges are always found to be in nearly parallel planes, *b–b*, *b–b*.

In the straight-limbed Proboscidia and Dinocerata, by this means the proximal articular facets of the humerus come to lie almost directly upon the top of the shaft. In the Dinocerata the articular facets are slightly more inclined to the axis of the shaft than in the Proboscidia. The difference, however, is

only 4°, the elephant angle being 105°, while the Loxolophodon angle is 109°. This greater inclination is trifling when compared with the 130° of inclination seen in the rhinoceros, but it indicates that the humerus of Uintatherium was slightly more inclined and the elbow was slightly more bent than that of the elephant; the limb as a whole was therefore slightly more bent both in the standing position and in extreme extension.

The motions and positions of the elephant's limb, as shown by instantaneous photography, are very surprising. It is safe to say that the study of the skeleton alone would have given us a very faulty conception of this animal. The two most striking features are the great play of the wrist joint and the straight-

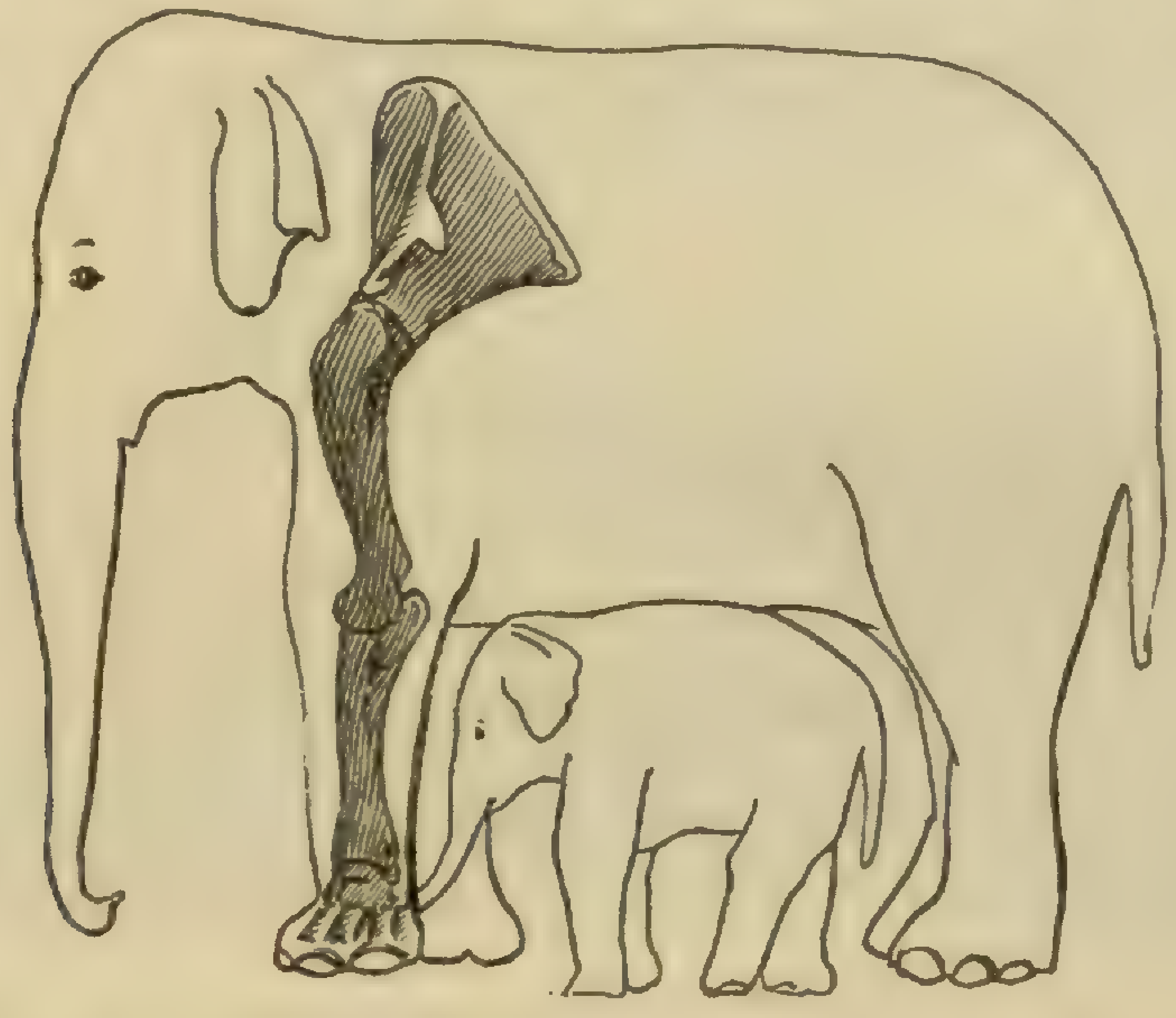

FIG. 5. — Diagram showing position of fore limb in "Hebe."

ness of the limbs. Fig. 5 is an accurate tracing of a photograph of "Hebe," in a standing position, taken by Schreiber & Sons, of Philadelphia. The skeleton fore limb, reduced to the same scale, is sketched in, with as much flexure at the elbow joint as a fair allowance for the enveloping muscles will permit. It shows that, in standing, the bones of the fore limb are in a nearly vertical line from the scapula downwards. The elbow joint is, in fact, much straighter in extreme extension than we should have inferred experimentally by fitting the bones of the arm and fore arm together.

The conclusion is that the motions and positions of the limbs in the ponderous representatives of the most highly

specialized Dinocerata were very similar to those of the modern elephants. The hind limb was as straight as in the elephant, and the fore limb in standing was a trifle more bent. A fore

Fig. 6. — Same animal as in Fig. 4, showing sharp flexure at the wrist. (By permission, from a copyrighted photograph by Schreiber & Sons, Philadelphia.)

limb of Uintatherium in the Yale College collection gives evidence of considerable variation in this respect; some of the

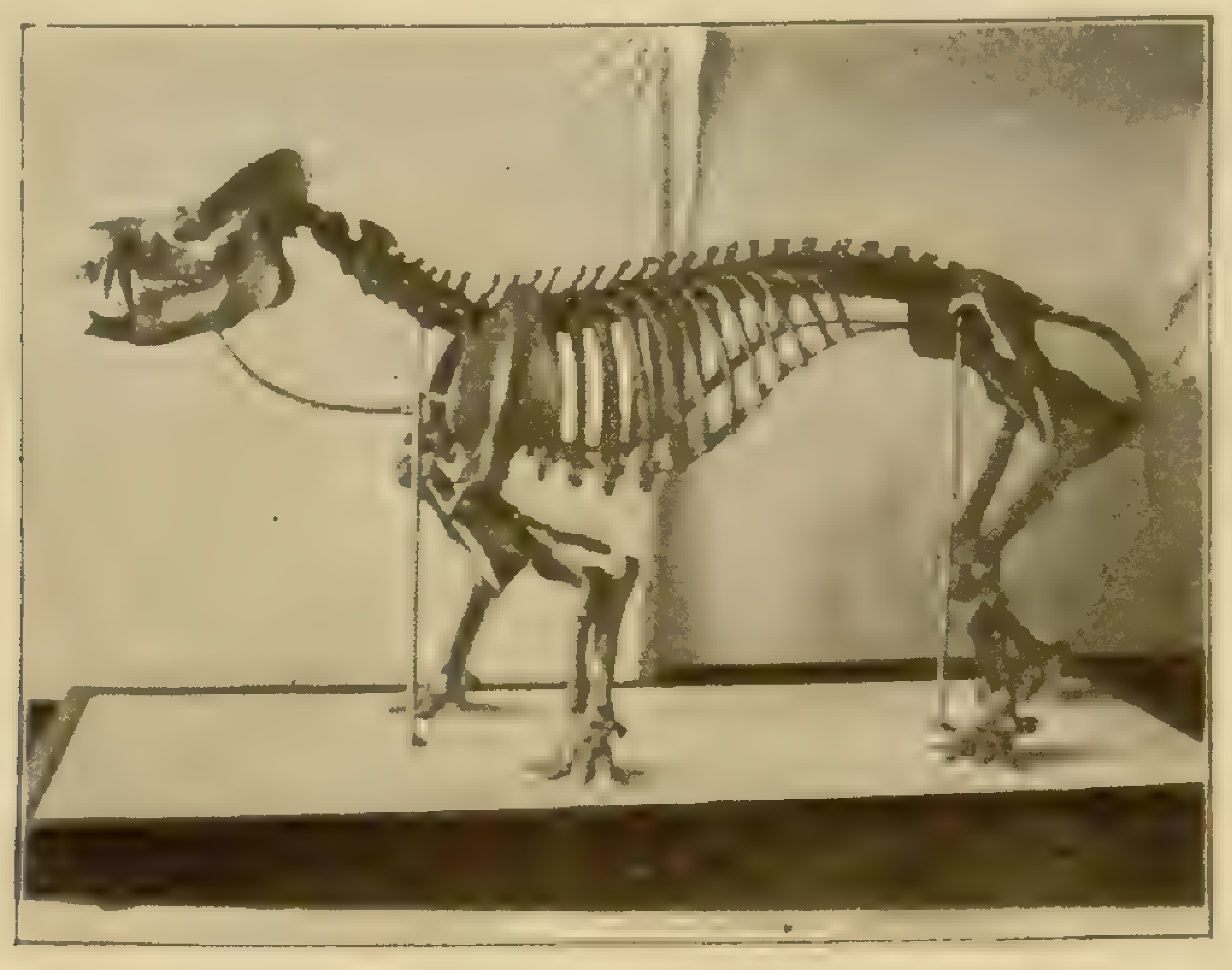

Fig. 7. — *Coryphodon testis*. Collection, American Museum of Natural History, showing marked primitive angulation of fore and hind limbs.

more primitive species, such as *Uintatherium mirabile*, were undoubtedly more straight limbed than others.

In the Coryphodontia of the lower Eocene, collateral ancestors of the Dinocerata, the angulation of the fore limbs is

almost as great as that in the rhinoceros. In the still earlier forms, such as Pantolambda, of the basal Eocene, the angulation is almost equal to that in the Creodonta, from which this entire order sprang.

There is no doubt, therefore, that in my restoration of Loxolophodon, as well as in Professor Cope's restoration of the same animal, which was published later, the fore limb is somewhat too straight. On the other hand, Professor Marsh seems to have given the limb too much flexure in his restoration of *Uintatherium* (*Tinoceras*) *ingens*, a slightly older type than Loxolophodon.

The more vertical position of the limb is secondary, it is observed, in all large quadrupeds. In the Titanotheres it has not proceeded so far as in the above types of mammals. Among reptiles it is observed in the heavy quadrupedal Sauropoda.

The straightening of the limb is an adaptation designed to transmit the increasing weight through a vertical shaft. Correlated with it are the shifting of the facets into the direct line of pressure and the alteration of their planes from an oblique to a right or horizontal angle with relation to the vertical shaft.

THE SPECIFIC GRAVITY OF SOME FRESH-WATER ANIMALS IN RELATION TO THEIR HABITS, DEVELOPMENT, AND COMPOSITION.[1]

STEPHEN R. WILLIAMS.

THE questions I have examined are: What is the specific gravity of animals living in water, and what bearing does their specific gravity have on their life histories?

These questions suggest the underlying problem of the specific gravity of protoplasms. I say protoplasms because two eggs, though very similar in appearance, existing under exactly the same conditions, may develop into two widely different animals.

The first part of my paper deals with the specific gravities of adult animals. The second part is a description of a number of series of growing tadpoles, in which I have ascertained, besides their specific gravity, their dry weight, and thus the percentage of water they contain. The third section of the paper has reference to the location of the water which, as shown by Davenport ('**97–99**, p. 285), is imbibed by the tadpole in its period of rapid growth.

I.

Protoplasm with its structure and functions very little specialized will be best found in simple, free-swimming water animals. An Amœba is apparently a body of simple protoplasm, and if a method delicate enough to find its specific gravity were devised, we should know very exactly how amœbic protoplasm compares in weight with its own volume of pure water, and how much effort would be necessary on the part of

[1] *Contributions from the Zoölogical Laboratory of the Museum of Comparative Zoölogy at Harvard College.* E. L. Mark, Director. No. 107.

the Amœba to maintain itself at a given level. I have, however, not been able to get the specific gravity of Amœbæ. But the larger soft-bodied animals, or animals with their shells removed, those with a small amount of foreign matter only, and especially embryos, offer favorable fields for the study of the specific gravity of protoplasms, and consequently I have made use of them.

Any information concerning the specific gravity of organisms will be of use in explaining motions, positions, and possible foods of the different animals. Tadpoles, found to be negatively geotactic by Miss Platt ('99), are forced to swim or to adhere by their suckers if they wish to remain above the bottom. The attitude of young tadpoles in an aquarium, as they hang tail downwards while clinging to the glass sides by their suckers, is due to the pull of gravity. Outdoors very few young tadpoles are seen at the surface of ponds where one knows they abound, though older stages are common at the surface. Stir up the bottom, and the surface for an instant will be black with tadpoles clinging to the bottom débris. An individual of a later stage whose intestine is filled with gas floats, can no longer feed on the bottom algæ, and is outstripped in growth by his normal fellows.

In determining specific gravity I have used the method suggested by Davenport ('97–99) and used by Miss Platt ('99), that of placing the animal in a solution of its own density. The density of this solution can be varied at will by the addition of known amounts of the dissolved substance or of water.

I found it necessary to stupefy all the free-swimming animals experimented upon. For this purpose I generally used chloroform as the most convenient reagent. It is, however, unsatisfactory for Planaria, as the irritation causes a slime to be secreted, which buoys up the animal greatly. It causes Protozoa to burst. For Planarians a solution of CO_2 gas in water is excellent. For Stentors and Bursaria, being unable to stupefy without killing, I tried four per cent formol, absolute alcohol, CO_2, and chloroform, each without success. One-half per cent osmic acid and hot Perenyi's solution were fairly good, though most of the Stentors contracted to balls under the

influence of the reagents. Flemming's solution (weak) gave the best results. Many Stentors kept their extended shape and upon microscopic inspection appeared little altered.

I used gum arabic to regulate the density of my solutions, since, as suggested by Dr. Davenport, it is not injurious to animals immersed in it. It is more convenient to take a solution of high specific gravity and lower this gradually by adding water, than to increase the density by adding known weights of gum. Since different pieces of gum vary noticeably in density, two solutions made in exactly the same proportions may vary perceptibly in their buoyant effect. Consequently, to get a consistently acting medium which can be used throughout a series of experiments and which, each time it is made up, acts in about the same way, I made up a stock solution of 15 grams gum arabic and 30 cc. of distilled water. With a bit of camphor to keep out bacteria and a glass-stoppered vessel to prevent evaporation, there is no appreciable change in a month's time. A long pipette and a large test-tube, both marked in cubic centimeters on the outside, are the only apparatus necessary. The marking on the outside of the test-tube is absolutely essential to avoid uncertainty as to how many cubic centimeters have been added to the mixture.

In making a series of gum-arabic solutions I found that a gram of gum arabic when dissolved occupies between 0.66 and 0.72 cc. According to Landolt und Börnstein's Tabellen (**'94**), the specific gravity of the gums which are included under the name "gum arabic" varies between 1.31 and 1.45. The space that one gram occupies varies, then, between 0.763 and 0.689 cc. Comparing this with the observed volumes, I feel justified in assuming as an average the space value 0.7 cc. for one gram of dissolved gum arabic. On this basis the two tables which follow (p. 98) have been computed.

To make my stock solution I used 15 grams gum, which at 0.7 cc. space per gram occupies 10.5 cc. Adding 30 cc. of (distilled) water, the whole volume is 40.5 cc. The total weight is 45 grams, and weight divided by volume gives 1.111 + as the specific gravity of the mixture. The second number in the table is found by adding to 1 cc. of this mixture 1 cc. of pure

water and dividing the combined weight (2.111+) by the combined volume (2), which gives 1.056 —. For the third place in the table I added to 1 cc. of the original mixture 2 cc. of pure water, 3.111 + divided by 3 giving 1.037, and so on.

TABLE I. — SPECIFIC GRAVITY OF SUCCESSIVE DILUTIONS OF GUM-ARABIC SOLUTION.

Starting with 1 cc. of the stock solution and adding water 1 cc. at a time, 1 gram gum arabic being reckoned as the equivalent of 0.7 cc. volume.

Vol. added	0	1	2	3	4	5	6	7	8	9
Sp. gr.	1.111+	1.056−	1.037	1.028	1.022	1.0185	1.016	1.014	1.012	1.011
Vol. added	10	11	12	13	14	15	16	17	18	19
Sp. gr.	1.010	1.009	1.0085	1.008	1.0074	1.007	1.0065	1.006	1.0058	1.0055
Vol. added	20	21	22	23	24	25	26	27	28	29
Sp. gr.	1.0053	1.005	1.0048	1.0046	1.0044	1.0042	1.0041	1.004	1.0038	1.0037
Vol. added	30	31	32	33	34	35	36	37	38	39
Sp. gr.	1.0036	1.0034	1.0033	1.0032	1.0031	1.003	1.003	1.003	1.0029	1.0028

TABLE II. — MODIFICATION FOR USE WITH MINUTE ANIMALS.

By starting with $\frac{1}{4}$ cc. of the stock solution and adding $\frac{1}{12}$ cc. of water at a time, there is a smaller interval between two steps than is possible by the method of Table I.

Vol. added	0	.33	.67	1	1.33	1.67	2	2.33	2.67	3
Sp. gr.	1.111	1.083	1.0667	1.056	1.047	1.041	1.037	1.033	1.030	1.028
Vol. added	3.33	3.67	4	4.33	4.67	5	5.33	5.67	6	6.33
Sp. gr.	1.025	1.024	1.022	1.021−	1.019+	1.018+	1.017	1.0165	1.016−	1.015
Vol. added	6.67	7	7.33							
Sp. gr.	1.0145	1.014	1.013							

I experimented with a Beaumé's hydrometer to test how nearly the calculated values of my table matched the observed values of the hydrometer reading. One experiment began with water giving a hydrometer reading of 1.003. After dissolving 5 grams of gum in 240 cc. of this water, the hydrometer reading was 1.011. Deducting the discrepancy of the reading for the water taken, the true specific gravity of the solution was 1.008. (The exact reading is difficult to be certain of, because of capillarity. I took the mean of a number of readings made by myself and by other persons reading independently.) By dividing the volume, 243.5 (counting one gram space as 0.7 cc., as in the tables), into the weight, 245, the specific gravity resulting is 1.006 +. So the hydrometer read nearly 0.02 higher than the calculated specific gravity. In another test, to 238 cc. distilled water at slightly more than 1.000 sp. gr., 5 grams of gum were added, whereupon the hydrometer stood at 1.010. The calculated gravity is 1.0062+, a little less than 0.004 lower than the hydrometer reading. My results, then, are somewhat lower than the hydrometer would have made them. Taking into account the possible variation in the specific gravity of the gum, the two correspond quite closely.

To determine whether different parts of a gum solution were of the same density, I tested a single mixture: 254 cc. of a solution in which the hydrometer stood at 1.037 were divided into upper and lower halves as gently as possible. To each half was then added its own volume of pure water. Testing each, it was found that the lower half had a specific gravity of 1.020, while the upper read 1.018. As the solution had stood for some hours before being divided, I have assumed that the upper and lower halves of a solution were of the same density.

I have written above each sp. gr. value in the table the fraction of the starting amount (in case of Table II $\frac{1}{4}$ cc. of the gum-arabic mixture) which was added in the form of pure water. Taking, for example, the sixth place in Table II, the starting quantity of the mixture + 1.67 times its volume of water has a resulting specific gravity of 1.041.

In performing an experiment I put 1 cc. of the gum mixture into a test-tube with a long pipette, taking care not to draw

the gum above the 1 cc. mark and not to get any on the sides of the test-tube. Then I lifted the animals with as little water as possible into the solution. Where I knew that the specific gravity was less than 1.111, I took 1 cc. of water with them. Animals must be placed underneath the surface of the liquid, not dropped upon it, as some are buoyed up by the surface film, and so do not sink in solutions lighter than themselves. (Planaria and snails are thus supported in common pond water.) As it is very difficult to force out the gum adhering to the sides of the pipette, I made an allowance for the diminution of bore due to the adhering gum when adding the first cubic centimeter of pure water. By using this pipette to add the water, the gum mixture will soon be washed completely out into the test-tube, where it belongs.

The very heavy bodies — such as the eggs — and the very light ones — such as the older tadpoles (in general, the ends of the series) — afford the least accurate determinations of their specific gravity. To have a uniform standard for all, I assumed that in each case, after the addition of more water, an animal floated unless in sinking it touched the bottom or curving end of the test-tube.

I give my results in the form of a table (in which the animals are arranged according to their systematic relations) showing the number of specimens used, the average specific gravity, and the probable error. In the case of starred animals the solutions given by Table II were employed. This involved less rough treatment than by using the method of Table I.

There are five animals at the end of the table which were not tested in sufficient numbers to warrant comparison with the others.

All the free-swimming animals tested (excepting old tadpoles) tend, when quiescent, to be at the bottom and to rise must swim. That the lighter animals need less effort to swim is well illustrated by the two entomostracans, Cypridopsis and Simocephalus. Simocephalus moves without much effort and often very slowly in the water. Cypridopsis, on the other hand, must move rapidly and continuously or it sinks. It requires a distinct effort for a mosquito larva to get to the surface.

TABLE III.

Animal.	Number of Specimens.	Average Sp. Gr.	Probable Error.
*Stentor cœruleus Ehrbg.	72	1.016+	.0016
*Bursaria (*sp.*?)	66	1.0142	.00067
Hydra viridis L.	18	1.0095	.0013
Hydra { fusca L. or grisea L. }	6	1.0115	.0009
Cordylophora lacustris Allm.	5 heads	1.016	—
Planaria maculata Leidy	27	1.030	.0026
*Rotifer vulgaris Ehrbg.	15	1.021	—
Dero intermedia Cragin	36	1.022	.002
Cyclops albidus Jurine	16	1.0222	.0029
Simocephalus vetula Müller	17	1.0136	.0012
Cypridopsis vidua Müller	40	1.046	—
Culex (larvæ)	11	1.0185	.0002
Agrion larvæ	8	1.046	—
Aquatic fly larvæ (*sp.*?)	Many	1.0185	—
Physa (shell removed)	4	1.037	—
Nephelis (*sp.*?)	1	1.037	—
Asellus	3	1.037	—

When there, the surface film holds up the breathing tube with its spreading hairs. Whenever that support is lost the animal sinks. A Cyclops, when moving slowly, can be seen to move upwards with a jerking motion, then to sink slightly, then to jerk again, and so on. To remain motionless it must have its antennæ on the surface film.

A sinking animal, like a lifeless body, always falls with the heavy end downward. Many animals do not give special evidence in this direction. Cyclops usually sinks head downward, the tail being at an angle of 45° with the horizon. Hydra, unless unusually dense near the mouth (for instance, with food in the gastrovascular cavity), sinks foot downward. One with a bud sank bud downward.

In the tadpole the center of gravity changes position in the course of development. Up to a length of about 6 mm., it is in the head region, for that always sinks first. In later stages the center of gravity moves backward nearly to the root of the

tail, and tadpoles hang in the water with the tail at least 20° lower than the head. Many of the older ones seem no heavier than water. As soon as tadpoles begin to depend on food taken into the alimentary canal from without, the canal may become filled with air or gas, so that the animal floats belly up. This condition is not permanent, for I have isolated such floating tadpoles and they regained the bottom in the course of a day. I have seen a tadpole force from its mouth as many as twelve bubbles of gas. After attaining the length of 10–11 mm., the specific gravity of the tadpole depends much on the condition of the animal and on the development of the lungs. The refuse of the food in the alimentary canal, which consists of partially digested green water plants and many diatoms, may aid the animal in sinking. It certainly helps move back the center of gravity of the animal from the head region toward the tail.

II.

I have found the specific gravity of four series of tadpoles — two in the spring of 1898 and two in the spring of 1899. In each instance one series was the young of *Rana silvatica*, the other those of *Bufo lentiginosus*.

Table IV. — Specific Gravity of Frog and Toad Tadpoles.

Length in mm. =	Round Eggs.	2–3	4–5	6–7	8–9	10–11	12–13	14–15	16–16+
Rana silvatica, 1898	—	—	1.022	1.013	—	1.013	1.008	1.005	1.0055
Rana silvatica, 1899	—	1.111	1.11–	1.050	1.042	1.028	—	1.010	1.0052
Bufo lentiginosus, 1898	1.038	1.037	1.037	—	1.022	1.013	1.013	1.010	—
Bufo lentiginosus, 1899	1.037	1.037	1.030	1.022	1.017	—	1.016	1.016	—

This table calls for a few remarks.

I have been able to get no good determinations of the specific gravity of the eggs of the frog, for unless the egg envelope is removed, the specific gravity is too high; and if the envelope is removed from the youngest eggs, they break badly in the solution. The toads for the two years correspond fairly well with

each other, but the drop in specific gravity began a little earlier in their growth in 1899 than in 1898. There is a great difference in the two series of frog tadpoles, however, that of 1898 being much lighter. Even allowing for possible individual variation, the discrepancy is still too great to be accounted for by the faults of the method.

In looking back at the history of the two cases I find an explanation, which is based upon the work of Galloway ('98), who found experimentally that tadpoles of Rana, Amblystoma, and Bufo, kept in a warm place, imbibed proportionately more water in reaching a certain stage than did those kept in the cold. My first series of observations (Table IV) was made on eggs of *Rana silvatica*, which were obtained in cleavage stages March 26, 1898. These were kept *at room temperature* and hatched out March 28–31 (two to five days), some reaching the length of 7 mm. by the latter date. The second series was collected April 11, 1899, and kept *out of doors* in a shallow basin on the ledge of a north window. On April 22 they had reached a length of 7 mm. (after a period of eleven days), although still in the egg, and on that day I brought them into the room to hasten their hatching. Since the specific gravity of the embryos in the second series was throughout so much greater than that of the first, I infer that they must have contained much less water, therefore have had smaller lymph spaces and smaller vacuolated cell regions and water spaces. That is, the embryos reared in a higher temperature must have imbibed more water than those exposed to the lower temperature.

But while the specific gravity depends on the amount of water absorbed by the tissues of the embryo, it also depends on the amount of animal matter. The proportional amount of this animal matter present has been ascertained by weighing, desiccating, weighing again, and computing what per cent of the first weight the dry weight is. Since the animals from one mass of eggs vary individually, I selected them on the basis of length, not age, each observation being based on five or ten individuals of a given length.

In the series of tadpoles of frog and toad I have found the specific gravity, the average fresh weight, the average dry

weight, and the percentage dry weight. They were dried in a partial vacuum over sulphuric acid.

TABLE V. — RANA SILVATICA.

DATE.	NUMBER OF TADPOLES.	LENGTH. (mm.)	AVERAGE FRESH WEIGHT.	AVERAGE DRY WEIGHT	PER CENT DRY WEIGHT.	SPECIFIC GRAVITY.
April 13	5	2½	.00328	.00136	41.4	1.11 +
April 13	5	4	.00344	.00132	38.37	1.11 –
April 21	5	6	.00402	.00142	34.8	1.055
April { 22 / 25	10	7	.00448	.00126	28.1	1.055–1.037
April { 18 / 27	10	8–9	.00540	.00105	19.4	1.037–1.022
April 21	5	9	.00592	.00110	18.58	—
April 21	10	10–11	.00794	.00110	13.9	1.022–1.018
April 22	5	13–14	.02730	.00144	5.25	1.010
April 26	5	16–17	.04100	.00208	5	—
April 28	5	16	.05090	.00230	4.5	1.009–1.0065
May 1	5	20	.06750	.00356	5.2	1.007

TABLE VI. — BUFO LENTIGINOSUS.

DATE.	NUMBER OF TADPOLES.	LENGTH. (mm.)	AVERAGE FRESH WEIGHT.	AVERAGE DRY WEIGHT.	PER CENT DRY WEIGHT.	SPECIFIC GRAVITY.
May 1	10	3–4	.00115	.0005	44.3	1.037
May 1	10	4–5	.00217	.0007	32.2	1.037
May 2	10	6	.00339	.00065	19.1	1.025
May 3	10	7	.00354	.00062	17.5	1.022
May 10	10	8–10	.00867	.00077	8.8	1.018–1.016
May 10	10	10	.01477	.00122	8.2	1.016
May 10	10	12	.02496	.00196	7.8	1.018–1.016
May 11	10	13–15	.04455	.00327	7.3	—

These tables show:

1. That the animals, while continually increasing in total weight, really decrease in dry weight up to the age (about 10 mm. long in the frogs) where they take in food from without.

2. That the specific gravity decreases with the increase in volume, as one would expect if the increased volume is due to imbibition of water.

3. That the percentage of dry weight continues to decrease even after the absolute dry weight, owing to the acquisition of food from without, begins to increase. A similar set of results expressed in the form of a curve is given by Davenport ('**97–99**, p. 285).

In the case of the toad series growth was so slow that for the greater lengths (8 mm. and upwards) I took toads from out of doors. All had reached the feeding stage, the intestines of all being full, and since the conditions were the same and the lengths not greatly different, their specific gravities were essentially the same.

The preceding table was based on developing forms of Amphibians. I give also for comparison the relation which exists between dry weight and total weight in a few individuals of essentially adult fish.

Table VII.

	Number of Individuals.	Length. (mm.)	Live Weight.	Dry Weight.	Per Cent Dry Weight.
Fundulus	2	32	.2090	.0454	21.7
Fundulus	1	35	.2780	.0622	22.6
Fundulus	2	44	.6336	.1490	23.6
Gasterosteus	1	30	.1449	.0358	23.4
Gasterosteus	1	60	1.4041	.3179	28.6

These fish were dried ten days. The larger the fish is, the greater the per cent of dry weight.

As one would expect, the armored stickleback has a greater per cent dry weight than Fundulus.

III.

The last section of the paper has reference to the location of the imbibed water in the tissues of the tadpole. I give three

cross-sections from tadpoles of *Rana silvatica* at different ages. They are in black and white, all solid cell tissue being printed black. They are all outlined with the camera to a magnification of 30 diameters.

As nearly as possible they are from corresponding regions of the body — the region just back of the thickened auditory epithelium. No. 1 is taken from a specimen 2½ mm. long.

FIG. 1. — Cross-section *R. silvatica*, 2½ mm. long, magnified 30 diam.; tissue black, spaces white.

Plainly there are here very few spaces which may contain water or lymph. The cells also are very crowded and show no vacuolation.

No. 2 is from a 10 mm. tadpole. The change is remarkable, especially in the development of the highly vacuolated mesenchyme. The neural canal is larger, while the cross-section of nervous tissue is not greatly increased.

The cavities of the œsophagus, intestine, and liver are large, and the pronephric tubules also increase the interior space.

As the best example of the change in individual cells, I call attention to those of the chorda, which are very strongly vacuolated.

FIG. 2. — Cross-section *R. silvatica*, 10 mm. long, magnified 30 diam.

The cross-section (Fig. 3) from a 20 mm. tadpole shows that, except for the cluster of cells on the right which forms the limb bud, the area of solid tissue has decreased greatly. The epidermis is very thin compared to either of the other examples, and the œsophagus and intestinal wall are not more than half as thick as in the preceding stage.

Table V shows that the actual tissue (dry weight) in specimen No. 2 must have been less than in No. 1. That the actual

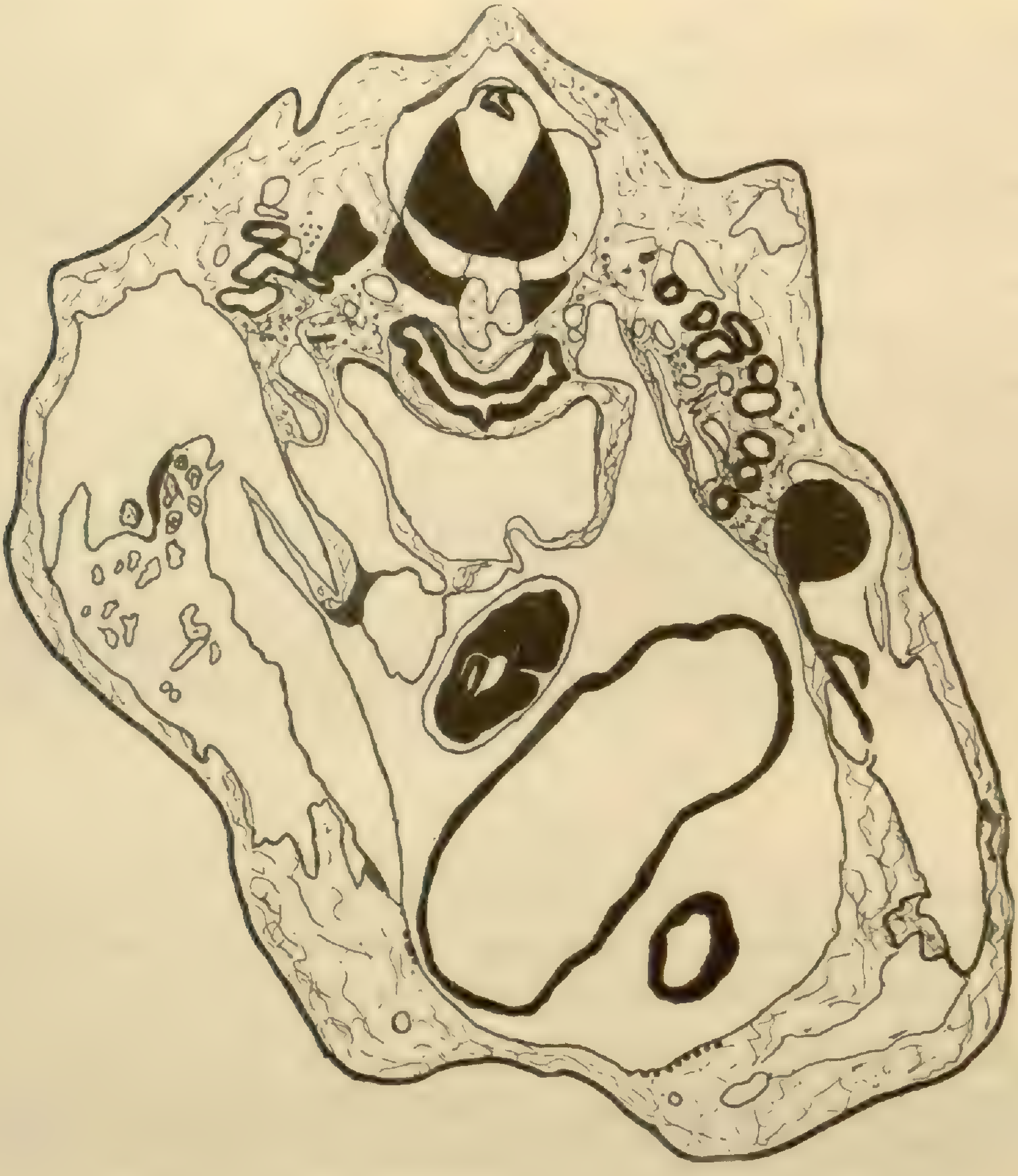

FIG. 3. — Cross-section *R. silvatica*, 20 mm. long, magnified 30 diam.

tissue is greater in the 20 mm. tadpole is due to the fact that the tadpole has been taking in solid food for ten days.

RESULTS.

The specific gravity of certain fresh-water animals was determined and found to vary from 1.0095 (*Hydra viridis*) to a maximum of 1.0460 (Cypridopsis).

The movements of an animal are closely related to its density, and there is also a correlation between density and food habits.

Of the animals tested, Stentor may represent a typical case of specific gravity in little modified protoplasm. The heavier animals certainly have some specialized tissues which are

denser, while in the case of Hydra, the lightest, the extreme vacuolation of the inner layer may well indicate a less representative character of the protoplasm.

In the case of the developing animal the chief tissue to absorb water, and, therefore, the tissue of most rapid increase in bulk, is the mesenchyme. All of the walls of the internal organs, however, grow thinner and less dense as the animal increases in size.

This work has been carried on under Dr. Charles B. Davenport, whose suggestions are the basis of anything of value it may contain.

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THE MOSAIC OF SINGLE AND TWIN CONES IN THE RETINA OF FISHES.[1]

CARL H. EIGENMANN AND GEORGE DANIEL SHAFER.

THE eyes of fishes have served as the basis of numerous papers. A list of these dealing with the eye in its macroscopic aspect has been furnished by Ziegenhagen ('95), while those dealing with its minute structure have been enumerated by Krause ('86) and Cajal ('94).

During recent years the efforts have been largely in the direction of the application of the methods of Golgi and Ehrlich, chiefly to work out the vertical relationships of the various layers of the retina. The present paper will be devoted to the horizontal relationships of two elements in the retina of fishes, *i.e.*, the single and the twin cones.

Both elements are well known, and their relative positions have also received mention, as will be seen from the following summary of the literature.

The twin cones arise from two cells placed close together; their nuclei are usually just within the outer limiting membrane. The cone bodies are pressed together so that the faces in contact are flat. The outer segments are separate. The line joining the centers of the two elements of the twin cone may be termed the axis of a twin. The single cones vary greatly in their relative thickness when compared with the components of a twin. Quite frequently they are much thinner than the latter, and in some other instances their structure is strikingly different. In the eye of Zygonectes, for instance (Eigenmann ('99), the basal portion of the single cones contains refractive granules, increasing in size outward where the series ends in a lenticular vacuolated body separating the granular from the distal portion. The twins do not possess these granules. In

[1] *Contributions from the Zoölogical Laboratory of the Indiana University, No. 26.*

Coregonus the outer segments of the single cones have a central deeper staining core. In this respect they agree with the rods. One of us was in doubt concerning these single cones, inclining to the opinion that they were rods (Eigenmann ('99), p. 548).

The rods are not taken into consideration in this paper. It may be said, however, that generally the number of rods is inversely proportional to the number of single cones.

The eyes examined were taken, for the most part, from museum specimens preserved in alcohol, and originally not intended for anatomical or histological purposes. The eyes were sectioned in paraffine, and the sections stained with hæmalum and eosine, or the Biondi-Ehrlich three-color mixture, or Weigert's hæmatoxylin; the latter gave good results even with the alcoholic material. No attempt has been made in this paper to describe the extent of variation in the patterns noted in different parts of the same retina.

The earliest notice that may have a possible bearing on the present subject is that of Guennelon (1686). According to Ziegenhagen, he noted that the retina of *Gadus æglifinus* is striped. We are not at all sure that this observation related to the arrangement of the twin and single cones.

The first undoubted notice that the twin and single cones may form a definite pattern was that of Hannover ('43), who figured the pattern of the "Rödspetten" and of the pike. Both patterns figured are those of our diagram *D*. We find the pattern of the pickerel to be that of diagram *H*.

Much later, Müller ('72, p. 59) says that in *Perca fluviatilis* the twins are in excess, with such an arrangement that each single cone is separated from its neighbor by the twins, not counting the rods. He also stated that in many fishes only single cones exist.

Nunneley ('58) and Krause ('68) described cones in the eel, and here, according to Krause, only single cones are found.

Friis ('79) examined a large series of fishes and found that in Accipenser and Anguilla only single cones exist. He found twin cones only in a large number of species, but states that in all of these, single cones are always to be found about the *ora*

serrata. Among the species that he enumerates as possessing twin cones only, there are certainly some in which single cones are regularly distributed. He found twin cones only in the retina of Scomber, Thynnus, Mugil, Gadus, Platessa, Hippoglossus, Rhombus, *Salmo trutta*, Coregonus, *Clupea harengus*, and *Clupea sprattus*.

He found both twin and single cones in *Belone rostrata*, Tinca, Ammodytes, Carassius, Abramis, Leuciscus. In the selachians examined, only rods are to be found.

Ryder ('95) discovered a regularity of arrangement of rods and cones in the larva of *Salmo salar*. The rods referred to are the single cones of authors. He believed this definite grouping of rods and cones to have some homology with the compound eye of the invertebrate. The arrangement he found is that of our pattern *D*.

Beer ('98) in a footnote calls attention to the fact that the cone mosaic is surprisingly plain and regular in Scorpæna and Blennius, and can be seen with the ophthalmoscope. He figures pattern *F*.

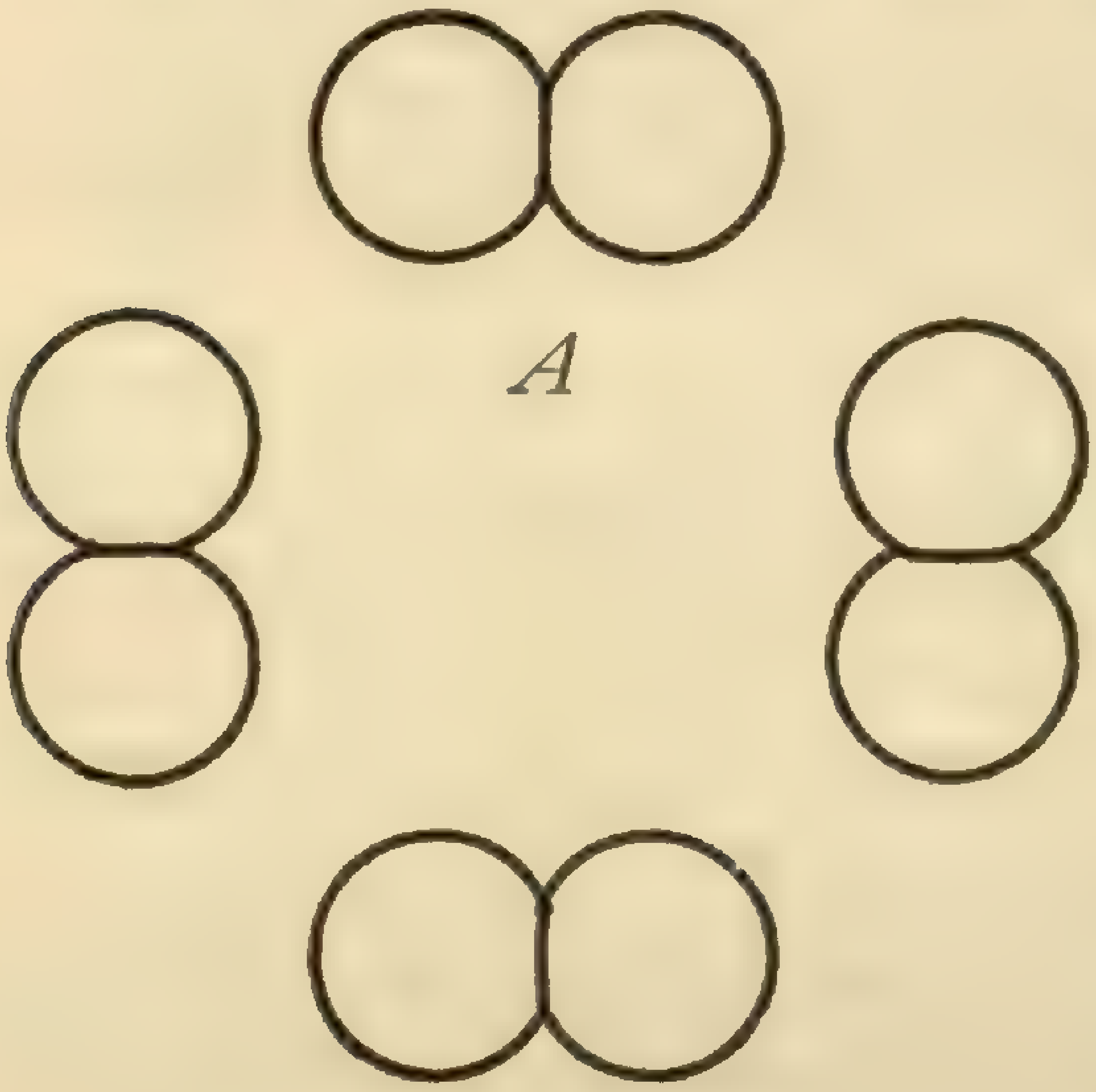
Eigenmann ('99) calls attention to the regularity of arrangement in Zygonectes. The pattern noted is *E*, a slight modification of that noted by Ryder in Salmo. He also found that in Chologaster the twins predominate over the single cones, and that in this genus the arrangement of the twins is a modification of pattern *C*.

Finally Eigenmann and Hansell ('99) in a short abstract state that the twin and single cones are arranged in a regular pattern, and that this pattern is either that described by Hannover and by Ryder for fishes, or a slight modification of this pattern.

The first notice of a regular alternation of twin and single cones is that by Hannover, and of the arrangement of twin and single cones, with a definite arrangement of the axes of the twin cones, is that by Ryder.

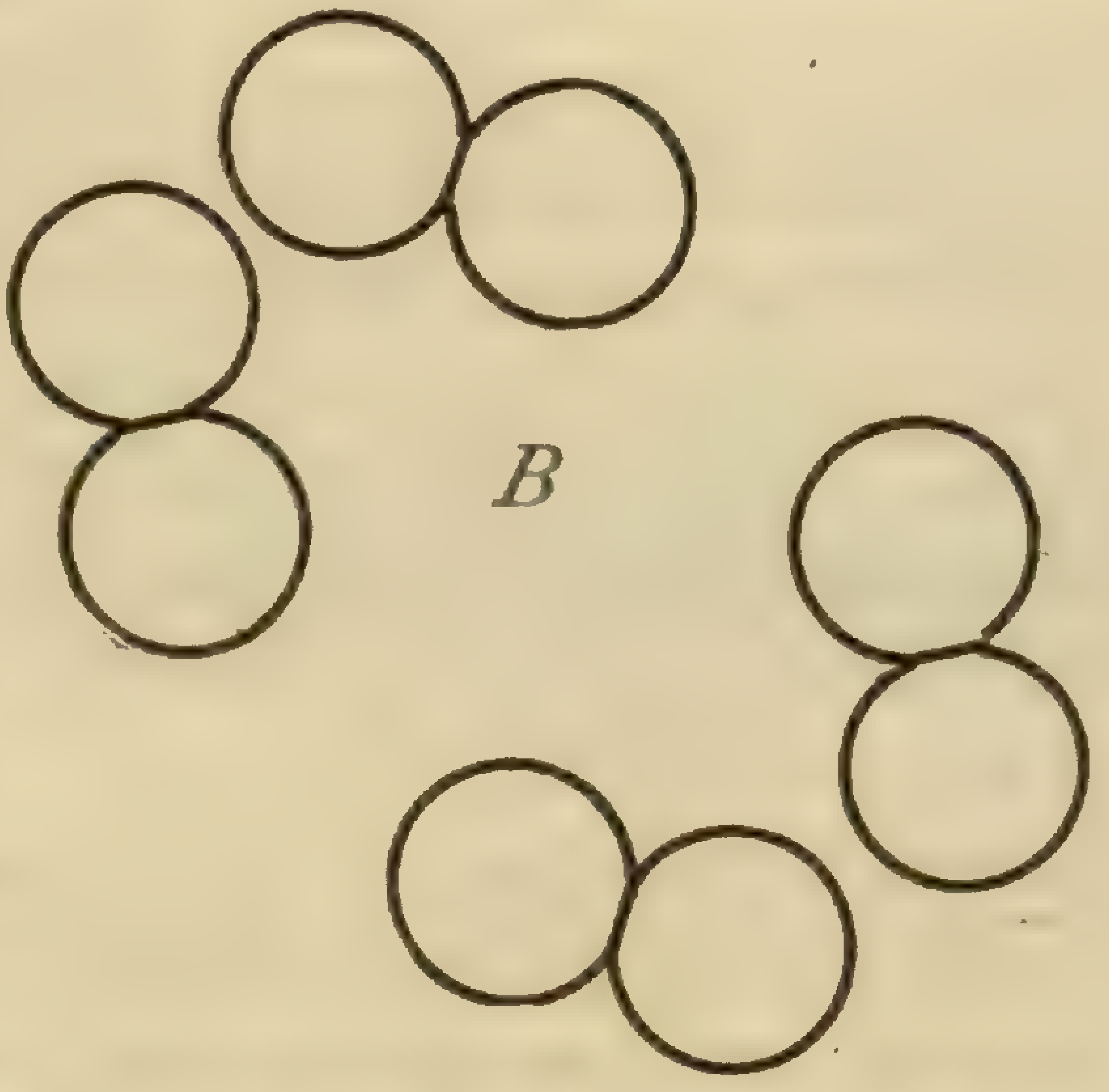
The work begun by Mr. G. Hansell under my direction has been continued by Mr. Shafer and myself, and a number of species have been examined to date. Mr. Hansell's work is incorporated in the present paper, credit being given under the

head of the species he examined. We have found that the arrangement of the twin and single cones is remarkably constant for any given species,[1] and that the arrangement differs considerably in different groups of fishes, but that the patterns in all of the species examined can be derived seriatim from one or the other of the patterns.



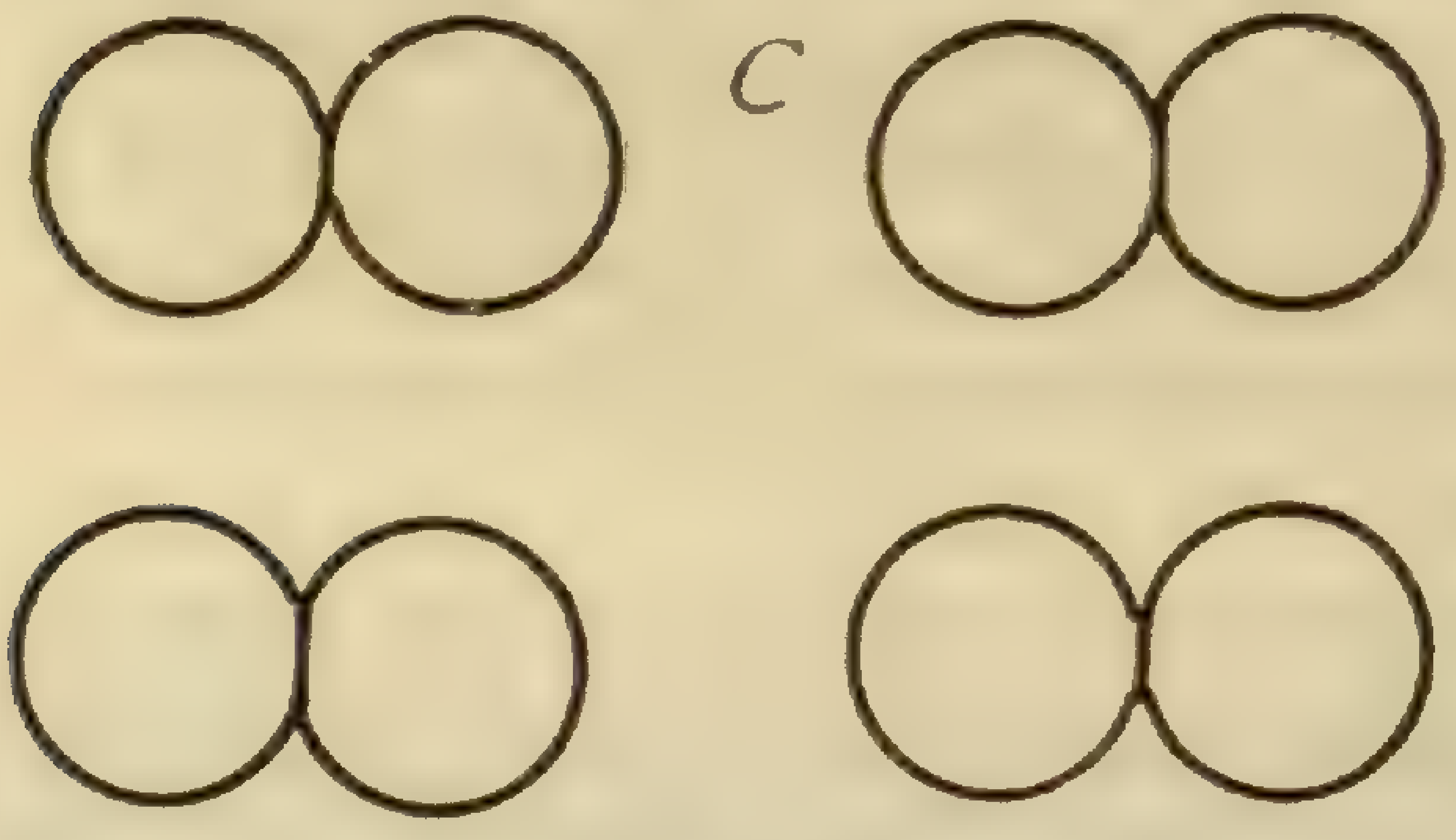
A

Pattern *A*, the pattern from which all others can most readily be derived, has not been found in any species as yet, but slight modifications of it have. In this simple pattern there are twin cones only, and the axes of alternate rows of twins are parallel, while those of neighboring rows are at right angles to each other. A series of squares are formed in this way whose sides are the extended axes of four twin cones.



B

Pattern *B* is produced by a slight twisting of the axes of the twins so that if extended they would form a rhomb. This pattern was found in *Scorpæna porcus.* The angles of the rhomb measure 53° and 127°. The actual conditions found in the eye are shown in Fig. 1.



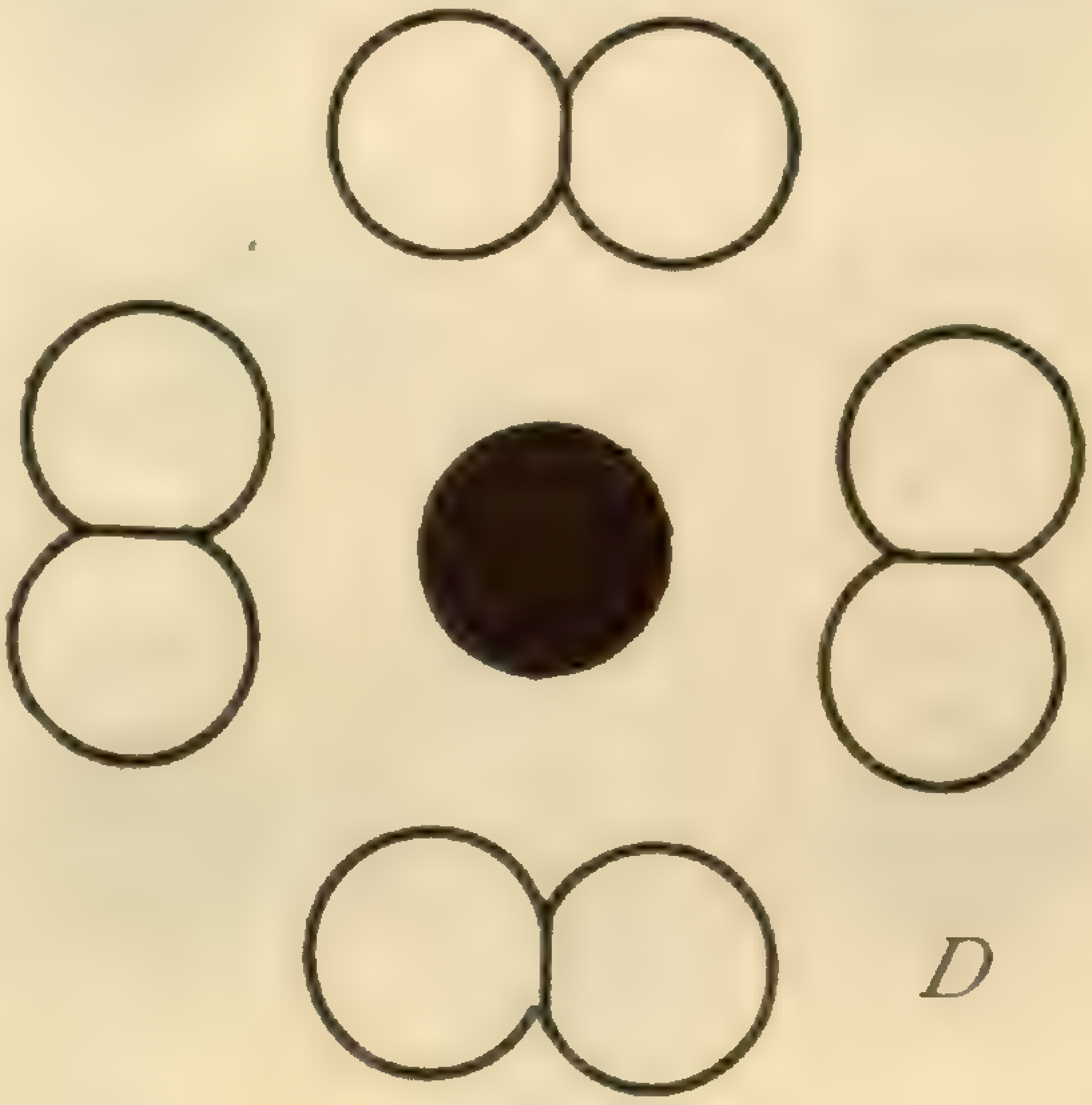
C

Pattern *C* is produced from *B* by a still further twisting of the axes of the twins till they are parallel

[1] The variation of the pattern in different parts of the same eye will be dealt with in a later paper.

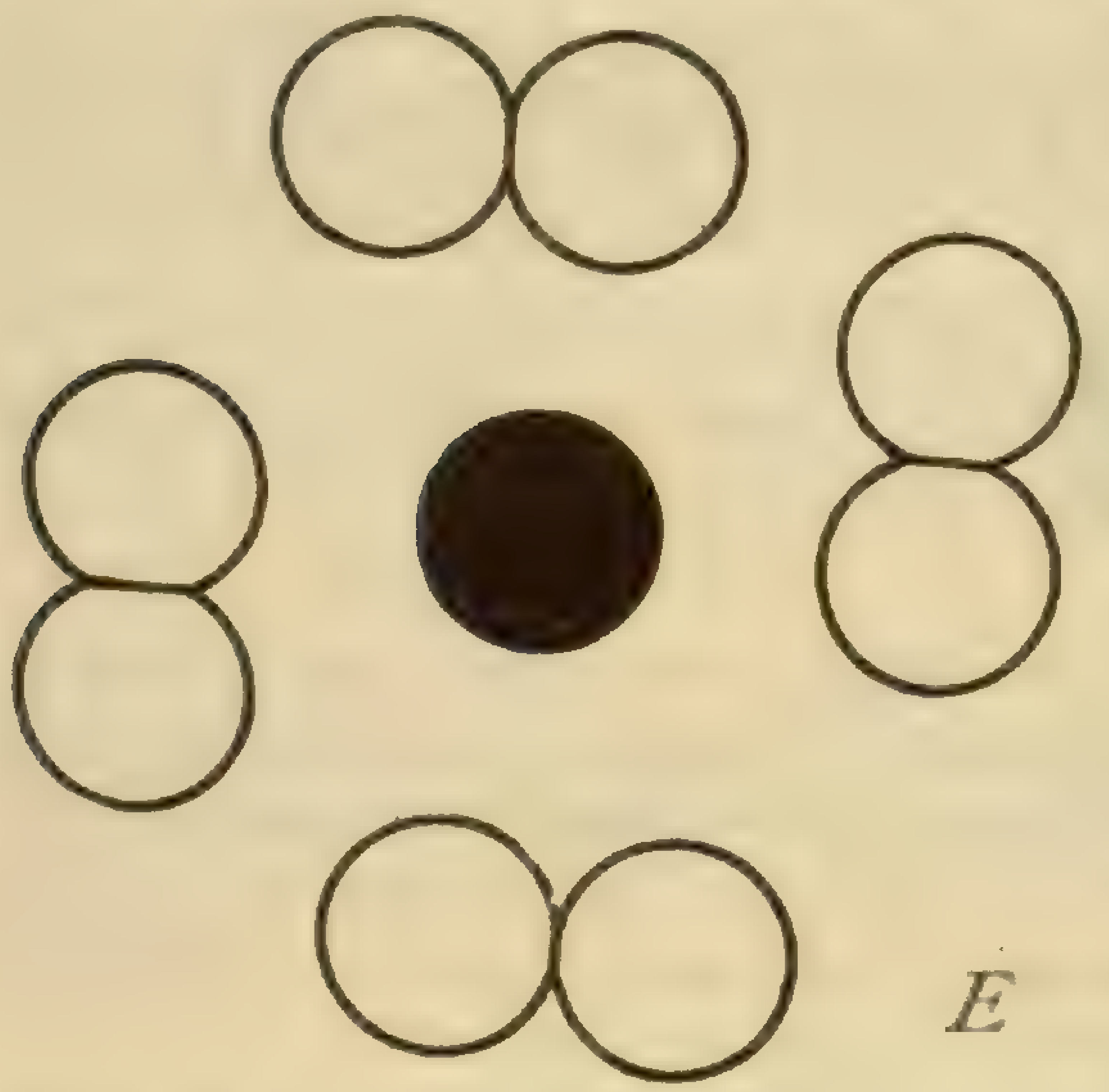
to each other. This pattern was found in *Sebastodes elongatus* (Fig. 2). A similar but less regular arrangement was found by Eigenmann ('99) in *Chologaster cornutus* (Figs. 3, 4[2]). In the latter case there are also some single cones irregularly disposed among the twins.

Pattern *D* is formed from *A* by the addition of a single cone in the center of the square. This pattern has been known longer than any other, and is evidently the one described by Müller for Perca, in which he says "each single cone is separated from its neighbor by twins." It is found in the American and the European species of Perca (Fig. 5), in which the single cones are of nearly the same size as the components of the twins, and in Micropterus (Fig. 9). It was also found in *Etheostoma cœruleum* (Fig. 6), *Apomotis cyanellus* (Fig. 7), and *Pimephales notatus* (Fig. 8). The three last eyes were prepared and the figures drawn by Mr. Hansell.



D

The closeness of the elements in the pattern and the size of the elements are seen to differ in the various species examined.

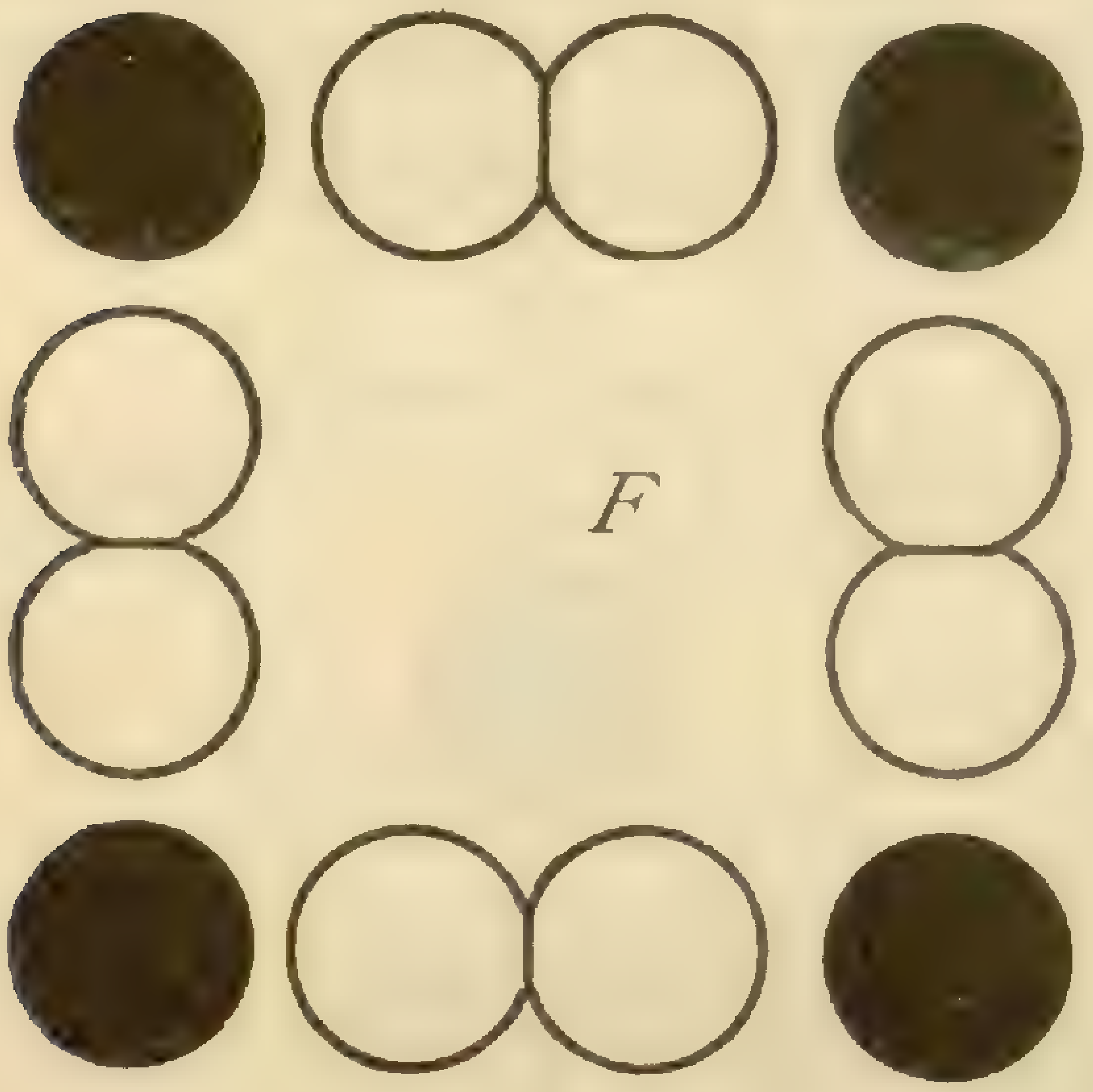


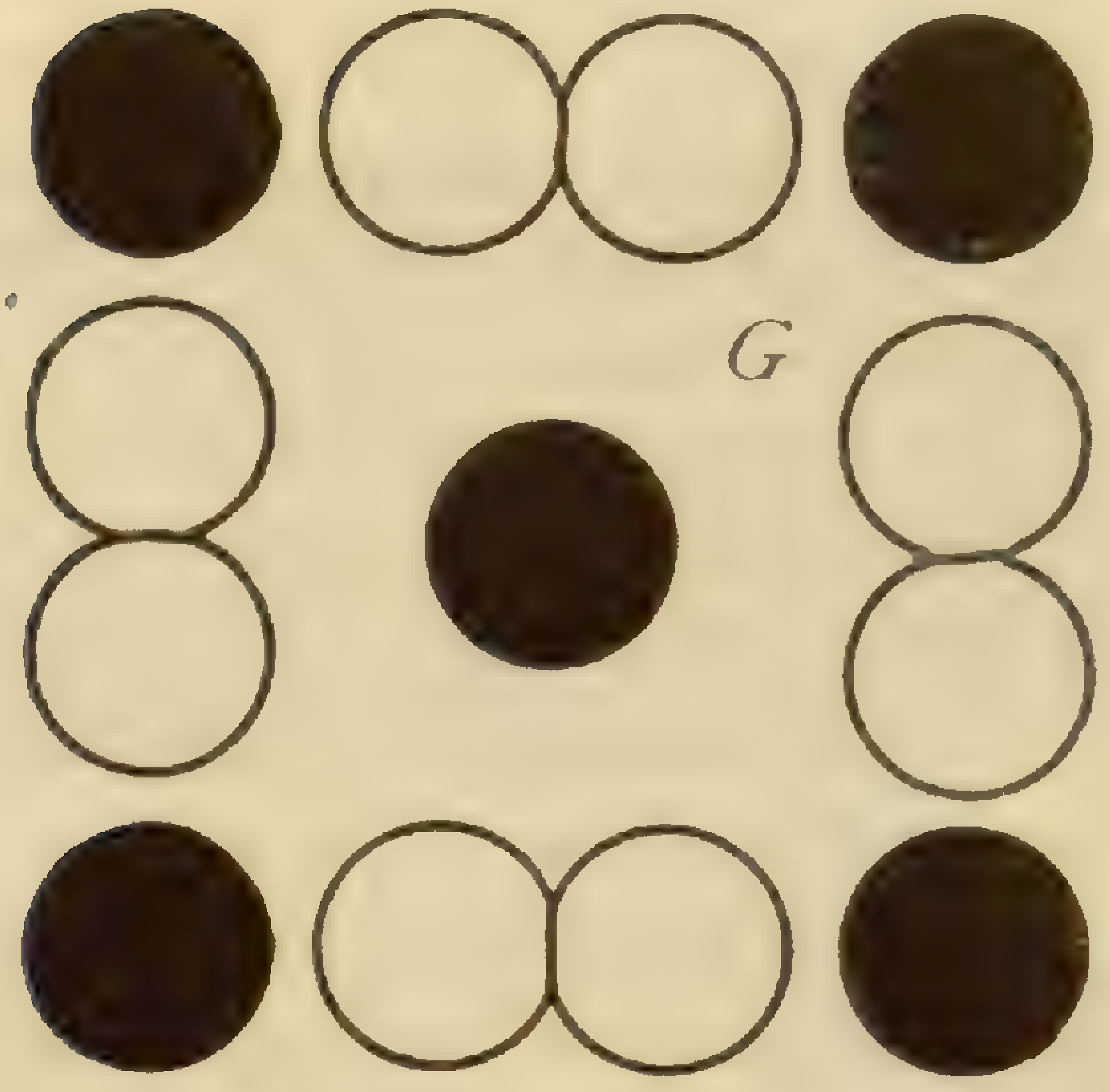
E

Pattern *E* is but a slight modification of pattern *D*, in which some of the twins have migrated along the faces of the squares so that while their axes, if extended, still form squares, the lines separating the twins, if extended, form parallel lines instead of a continuous line. This condition was found by Eigenmann ('99) in Zygonectes (Figs. 10, 11).

Pattern *F* is formed by adding a single cone at each angle

of the square of pattern *A*. This gives us rows which answer to the description of Müller quoted above, but this pattern evidently was not the one observed by him. This pattern was first figured by Beer ('98) in Blennius, in which the large hollow square formed is filled by a great number of rods. The actual pattern found in the eye of Blennius was of interest (Fig. 12), inasmuch as double series of twin cones, one with axes horizontal and one with axes vertical, were, in several places, interpolated without disturbing the pattern already present.

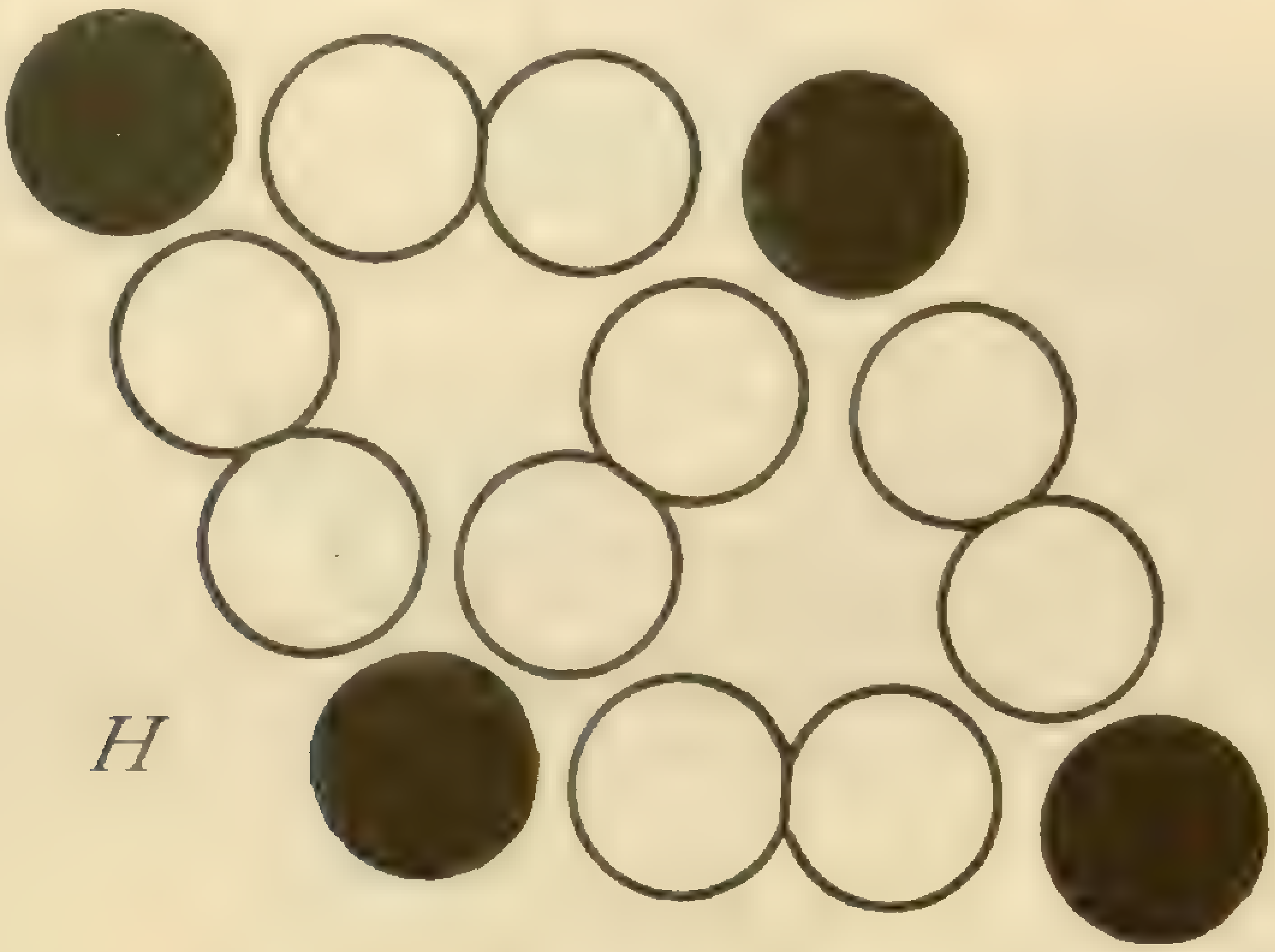




Pattern *G* is formed by adding a single cone in the center of the hollow square of pattern *F*. This pattern was described by Ryder ('95) in Salmo. A pattern but a little less regular was found in some larval Coregonus (Figs. 13–17).[1]

[1] Inasmuch as these specimens of Coregonus were of interest in several respects, a brief note may be added to the above. The material examined consisted of recently hatched larvæ preserved in 70 per cent alcohol. The material came from the hatching station of the U. S. Fish Commission. The heads were imbedded in paraffine, sectioned and stained in hæmalum-eosine or in Biondi-Ehrlich's three-color mixture. Both methods gave excellent results. The twins alternate with the single cones in such a way that each is surrounded by four twins whose dividing plane points toward the space occupied by the single cone. The pattern is not mathematically accurate in the eye. Many of the twin cones are twisted, as it were, on their axes, and occasionally an extra single cone is to be found besides the single one in the unoccupied space between four twin cones, *i.e.*, at the angles of the square. Each component of a twin cone consists of a slender outer segment, a much thicker body, and a more or less vacuolated base

Pattern *H* is the most complicated found so far. The square of pattern *F* is converted into a rhomb with angles of 60° and 120°, and a twin cone is added whose axis forms a diagonal between the nearer angles of the rhomb. This makes two equilateral triangles whose sides are formed by twin cones, and



H

whose angles are occupied each by a single cone. This pattern has been found in Lucius (Figs. 18, 19).

No suggestion is offered as to the significance of these various patterns or the causes that have led to the various modifications.

In several species we have not so far been able to make out any regularity or, in fact, the nature of the cones. These are the catfishes and Catostomus, one of the suckers.

resting on the outer limiting membrane (Fig. 1). Below this membrane and exactly opposite each cone is a conical nucleus with a diameter less than that of the cone. With Biondi-Ehrlich the nuclei are stained a blue purple and the rest of the structures pink, so that there is no difficulty in separating parts. The single cones differ from the twins in possessing a central deeper staining core in the outer segment (Fig. 13). Besides these nuclei there are a few others, more spherical and slightly larger, just within the inner ends of this layer of cells — the rod nuclei. This inner layer of cells seems most abundant about midway between the optic nerve and the *ora serrata*. There are about two and one-half times as many of the outer nuclei as of these inner.

EXPLANATION OF FIGURES.

(*Eigenmann, Figs. 1–5 and 10–19; Hansell, Figs. 6–9.*)

All the figures were made from paraffine sections by the aid of the *camera lucida*. All but one of the figures were made under a magnification either of the Zeiss apochromatic 2 mm., or the Bausch and Lomb, $\frac{1}{12}$ objective.

(1) Pigment epithelium; (2) rods and cones; (3) outer nuclear layer; (4) outer reticular layer; (5) horizontal cells; (6) inner nuclear layer; (7) spongioblastic layer; (8) inner reticular layer; (9) ganglionic layer; (10) optic fibre layer; *cn.*, cones; *cn. nl.*, cone nuclei.

FIG. 1. — Arrangement of cones in *Scorpæna porcus*, 2 mm.

FIG. 2. — The same of *Sebastodes elongatus*.

FIG. 3. — Vertical section through the retina of *Chologaster papilliferus*, depigmented with chromic acid and stained with Biondi-Ehrlich's three colors, 2 mm.

FIG. 4 *a, b, c*. — A series of three oblique sections through the retina, 2 mm. (*a*) Passes from the outer margin of the retina to the base of the cone bodies. (*b*) Passes through the basal segments of the cones. (*c*) Passes through the cone nuclei.

FIG. 5. — Arrangement of cones in the retina of Perca, $\frac{1}{12}$.

FIG. 6. — The same of *Etheostoma cæruleum*, $\frac{1}{12}$.

FIG. 7. — The same of *Apomotis cyanellus*.

FIG. 8. — The same in *Pimephales notatus*.

FIG. 9. — The same in *Micropterus salmoides*, $\frac{1}{12}$.

FIG. 10. — Vertical section through the retina of *Zygonectes notatus*, 2 mm.

FIG. 11. — Tangential section of the retina at the depth of the cone bodies, showing the arrangement of the cones, 2 mm. and 6 mm.

FIG. 12. — Arrangement of the cones in *Blennius ocellaris*, 8 mm.

FIGS. 13–16. — Successive tangential sections through the retina of a newly hatched Coregonus. The sections represent the posterior face of successive sections through the same part of the retina, 2 mm.

FIG. 13. — Passes through the outer part of the inner segments of the cones and the inner ends of the pigment cells.

FIG. 14. — Passes through the bodies of the cones and shows to best advantage the arrangement of the cones.

FIG. 15. — Section containing the inner ends of the cones and the outer ends of the nuclei belonging to them.

FIG. 16. — The middle of the cone nuclei.

FIG. 17. — Median section of the retina of a newly hatched *Coregonus sp.* (?), 2 mm.

FIG. 18. — Arrangement of the cones in *Lucius vermiculatus*.

FIG. 19. — Arrangement of the cones and cone cells in *Lucius vermiculatus*, the cones on the right, the cone cells on the left, of the figure, 2 mm.

4
1
a
2
2
b
c
3
1-
2
3
4
5-7
8
9
3
1
2
5
7
6
8
9
l
d.
cn.
rd.
12
11
1
2
3
4
5
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7
8
9
10
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3
4
5
6
7
8
9
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17
13
14
15
16
18
19

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Those which we have not been able to examine directly are marked *.

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NOTE ON THE GENITAL ORGANS OF ZAITHA.

THOMAS H. MONTGOMERY, Jr.

The hemipterous genus Zaitha has a remarkable structure of the inner genital organs, particularly in the male, which deserves to be made known. Leidy (*History and Anatomy of the Hemipterous Genus Belostoma*) assumes, as I believe most, if not all, entomologists have subsequently done, that Belostoma and Zaitha are closely related genera of the same family. He states (*loc. cit.*, p. 59): "The principal marks of distinction between Belostoma and Perthostoma (Zaitha) are in the form of the promuscis; the form of the antennæ; the form, comparative size, and situation of the patch of pubescence on the hemielytra; the form of the posterior tibiæ; and the size and form of the caudal setæ."

Leidy gives a figure (Fig. 6) of the male genitalia of *Belostoma haldemanum*, and describes the testes as "irregularly rounded masses, about two lines in diameter, . . . composed (each) of a single long convoluted tube. From the testicle passes off the vas deferens; at first narrow, it gradually enlarges as it passes backwards, is a little contorted, and finally joins the one of the opposite side to form the ductus ejaculatorius." Very probably Leidy assumed that these organs were similarly constructed in Zaitha, for he makes no reference to the latter in this regard.

An examination of the male genital organs of Zaitha has shown me that they are very different from those of Belostoma, as described by Leidy (I have not been able to procure Belostoma for personal study). Some fifty males of Zaitha were dissected by me recently (November and December), and the genitalia in all showed the following structure (Fig. *B*). Each testis (the testes are distinct from one another) is a large organ composed of five capsules or follicles (2 and 3). Each capsule is thickened in its anterior portion, but the posterior three-fifths

of its course is represented by a narrow tube. These five capsules are loosely connected together by tracheæ, but there is no tunic investing them; and their proximal ends are connected by terminal fibres (1). Distally they connect (at 4) and so join the vas deferens (5); and the vas deferens of the right side joining with that of the left, these internal organs terminate in the ductus ejaculatorius (6). The vasa are thin-walled, transparent tubes, considerably more delicate than the testes. In the drawing (Fig. *B*) I have represented the follicles more separated than they usually lie.

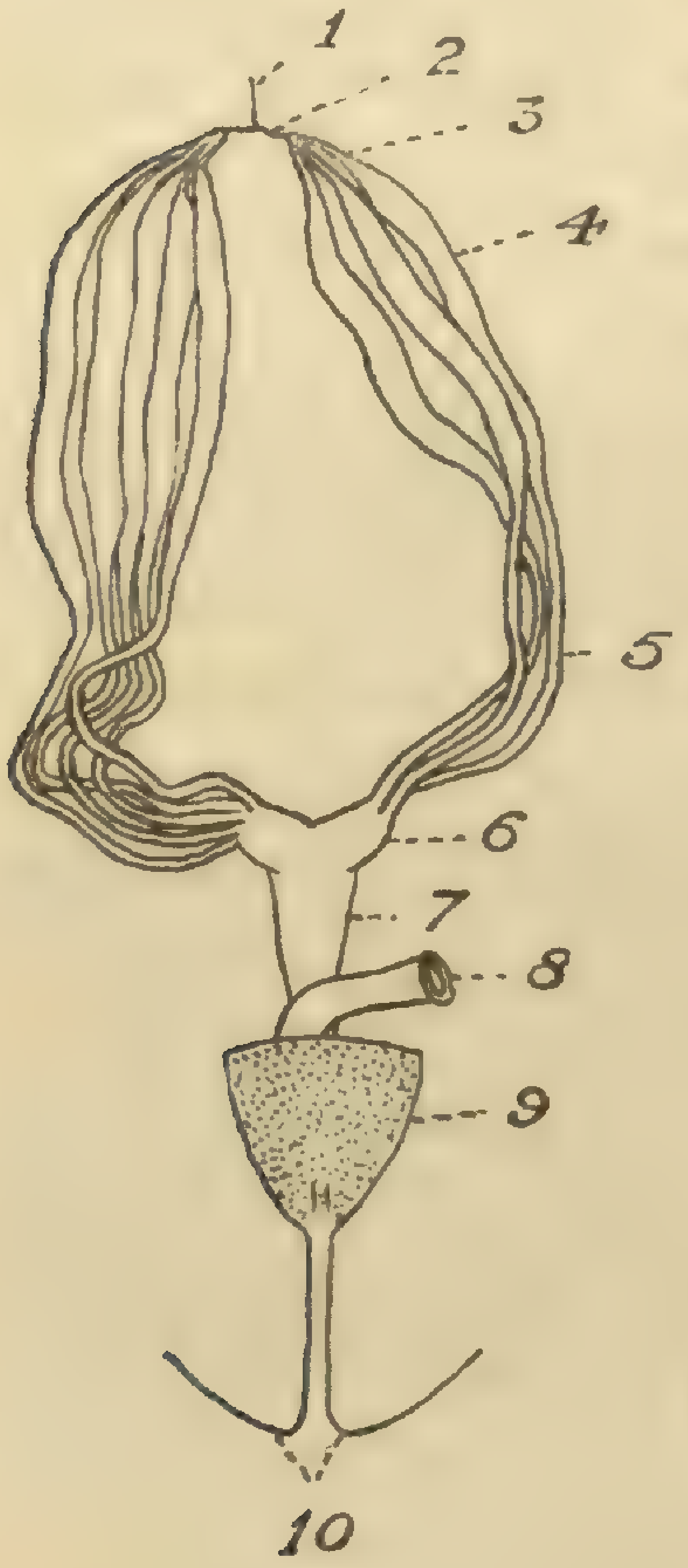

FIG. *A*.

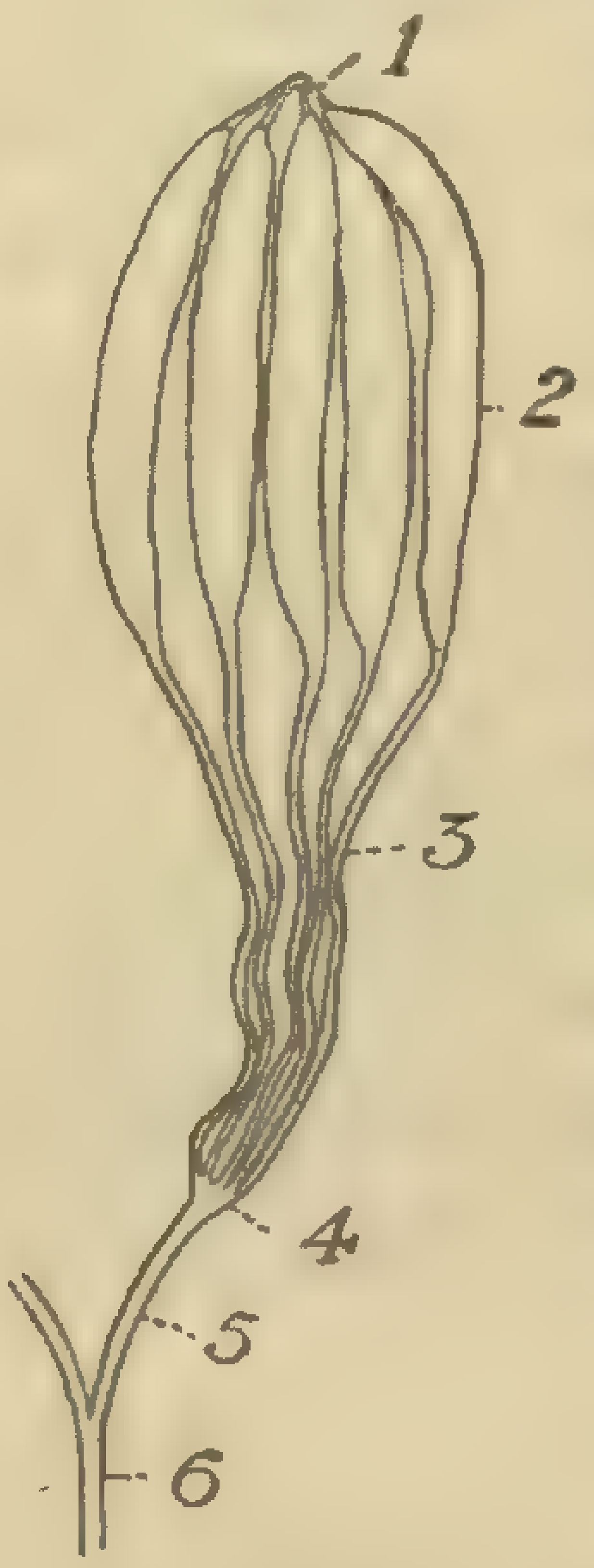

FIG. *B*.

In this description I call a follicle of the testis the two portions numbered 2 and 3 in the figure. In the testes studied in December both these parts are filled with spermatozoa, and I can find on sections no evidences of earlier spermatogenetic stages; consequently, the testes must be considered physiologically mature. But is the portion marked 3 really a portion of a testicular follicle, or is it not rather to be considered a vas deferens? If the latter alternative be correct, we should regard the five follicles (2) composing each testis to possess each a separate vas deferens (3), these five vasa deferentia joining posteriorly (at 4) to form a single vas (5). This point can be determined only by an examination of the organs in young individuals, with regard to whether in early stages spermatogonia and spermatocytes occur in the parts marked 3.

The ovaries differ in appearance according to the season of the year, *i.e.*, the state of growth of the ova. In June the ovarioles (follicles) are beaded in appearance. The small ova-

ries in December (Fig. *A*) have much the appearance of testes. Each ovariole is proximally attenuated (3), then enlarges (4), and distally is continued as a narrow tube (5). Perhaps, as in the testicle, the portion marked 5 should be regarded as an oviduct rather than a portion of an ovariole (follicle); in this case the portion marked 6 would be the undivided portion of the oviduct. Terminally is the vagina (7). (Fig. *A* represents all five ovarioles of the left ovary, but for the sake of clearness, only three ovarioles of the right ovary are shown; 8, the rectum; 9, the terminal ventral plate of the abdomen; 10, the outline of the posterior edge of the abdomen.) Proximally, the two ovaries are connected together by a fibrous thread (2, thread of Müller); and this thread is connected by another thread (1) to the pericardial wall. The dimensions in Fig. *B* should be doubled to be in the same scale of drawing as Fig. *A*.

From this description it will be seen that the female genital organs of Zaitha and Belostoma are quite similar, but that the male organs are very different. In Belostoma each testis consists of a single convoluted follicle; in Zaitha, of five distinct and well-separated, nearly straight follicles. Léon Dufour (*Recherches anatomiques et physiologiques sur les Hémiptères*) has not only given a most admirable description of the genitalia of Hemiptera, but also has insisted on their high value in taxonomy. Their worth seems to me also to be of great importance for classification. Consequently, when Belostoma and Zaitha differ so markedly in the structure of their male reproductive organs, we must conclude that these genera are by no means so closely related as they have been assumed to be; that in fact it might be proper to separate them into different families. Zaitha shows more relationship to Nepa in these structural characters than to Belostoma.

University of Pennsylvania, Philadelphia.

WILLEY ON THE ENTEROPNEUSTA.

MAYNARD M. METCALF.

Dr. Arthur Willey has made such valuable contributions to our knowledge of the morphology of the lower Chordata that it is with high expectations one opens his recent memoir upon the Enteropneusta.[1] He describes in considerable detail many points in the anatomy of three species of Ptychodera (two of them new), of two species of Spengelia (one new), and of a Tornaria, all from the South Pacific, and also describes as new and distinct species belonging to the genus Ptychodera two West Indian forms, from Bimini (in the Bahamas) and from Jamaica. This anatomical part of the memoir is full of details of considerable interest to the student of the Enteropneusta, but hardly of such a nature as to permit description in this review. The author's observations, however, serve him as a foundation upon which to rest some very far-reaching theoretical conclusions, and to these it may be profitable to direct attention, referring to so much of the anatomy as may be necessary for a correct understanding of the basis for these conclusions.

Willey's first proposition is that "the gonads and gill slits were primarily unlimited in number and coextensive in distribution, the gonads having a zonary disposition and the gill slits occupying the interzonal depressions. The primary function of the gill slits was the oxygenation of the gonads, their secondary function being the respiration of the individual." In support of this contention that in the lower Chordata the series of gonads once extended much further forward, while the series of gill slits extended much further backward, the gill slits lying between the gonads and serving chiefly for their oxygenation,

[1] Willey, A. *Zoölogical Results.* Pt. iii, Enteropneusta from the South Pacific, with Notes on the West Indian Species. Cambridge, University Press, May, 1899.

the author urges (1) that in the Enteropneusta and Cephalochordata the number of gill slits is indefinite, new ones being added posteriorly throughout life; (2) that the number of gill slits has become reduced not only among the Vertebrata, but even within the group of the Enteropneusta, since one species, *Ptychodera auriantiaca*, has as many as seven hundred pairs, while another species, *P. mimeta*, never has more than forty pairs, these representing the two extremes so far as known; (3) that in the intestinal pores and ciliated grooves of certain Enteropneusta we have vestiges of the former posterior gill slits of the now abbreviated series. The intestinal pores occur in six species belonging to four genera. These pores may lie either close behind the branchial region or at the posterior end of the hepatic region. Schimkewitsch and Spengel have suggested that these pores may in some way be related to gill slits. In the Ptychoderidæ the pores are absent, but instead of them we have a pair of ciliated grooves extending from the anterior end of the hepatic region nearly to the posterior end of the body. In two species "these are not simple longitudinal furrows, but undergo metameric or interannular sacculations," the saccules "strongly resembling gill pouches" not yet open to the exterior. Willey believes that the restriction of the gill slits to the anterior part of the body and of the gonads to the middle portion of the trunk took place after the development of a blood vascular system, which rendered the gonads no longer directly dependent upon the gill slits for oxygenation.

Certain species of Enteropneusta have two proboscis canals connecting anteriorly with the proboscis cœlom and opening posteriorly by two pores on the dorsal side of the stalk of the proboscis, near where it joins the collar. The distal extremity of each of these canals may be swollen to form a considerable vesicle, or "end sac." Secondarily, in some species one (or both?) of the proboscis canals may be interrupted, so that the end sac, while opening to the exterior, has no longer any communication with the proboscis cœlom. In certain adults, though not in the young, of one species, *Ptychodera carnosa*, Willey found that one of the two proboscis pores "may open" not onto the

posterior part of the dorsal surface of the proboscis stalk, as in other species, but "into the base of the medullary tube, somewhat behind the anterior neuropore."

"By a legitimate mental abstraction" Dr. Willey derives from this fact a "theory, as to the broad truth of which" he is himself "quite convinced," and which he states in these words: "The proboscis pore of the Enteropneusta is represented by and is homologous with the inner or cerebral opening of the neuro-hypophysial apparatus of the ascidian larva; the end sac of the Enteropneusta typically communicates internally with the cœlom, but within the limits of the group we find signs of its emancipation from the cœlom; the hypophysial canal of the ascidian larva has no relations with the body cavity, but it opens at one end into the medullary tube (cerebral vesicle) and at the other into the branchial sac at the base of the buccal cavity. Thus a special significance is given to the peculiar mode of origin of the ascidian subneural apparatus (gland and duct), and an explanation is forthcoming as to the apparent absence of anything like a proboscis pore in the ascidian larva." This adds another and startling hypothesis to the several that have been advanced as to the homologies of the ascidian neural gland. Allow me to refer for a moment to these.

Masterman's recent attempt to homologize the so-called notochordal pouch of the Hemichordata with the ascidian neural gland seems to imply a failure to understand the real nature of the latter organ. The notochordal pouch, so far as we can judge, is endodermal, a derivative of the pharynx. The neural gland of ascidians[1] is derived from the central nervous system, its duct is the anterior end of the central neural tube, and its aperture is usually regarded as the neuropore. The neural gland has no known relation to the endoderm, except that it opens into a portion of the pharynx which may be of endodermal origin, but which there is some reason to believe may be derived from the stomodæum.

[1] I say the neural gland of ascidians rather than of Tunicata, because the neural gland of certain tunicates, the Salpidæ, is of such a peculiar nature that it is difficult to compare it with that of the ascidians.

Willey's attempt to homologize a portion of one or both of the proboscis canals[1] and their pores with the ascidian neural gland seems even a greater exercise of the imaginative faculty, for these structures in Ptychodera are not only mesodermal, but are a definite portion of the cœlom. If they be homologous with one or both of the collar pores and collar canals, as seems not improbable, then they must be regarded as nephridial in their relationships, for Masterman has clearly demonstrated the nephridial nature of the collar canals in Cephalodiscus. Willey, however, does not claim that the proboscis canals and collar canals of Ptychodera have been derived from the ascidian neural gland, but rather that the gland in the ascidians has been modified from a more primitive condition similar to that in certain adult specimens of *Ptychodera carnosa*. How such a proposition can be reconciled with the facts of the development of the gland in the ascidians, where it is formed wholly at the expense of the larval neural canal, it is very difficult to see. Willey's statement that the "hypophysial canal" of the ascidian larva "opens into the medullary tube" is hardly accurate. It is morphologically a part of the medullary tube. Dr. Willey must have had these facts clearly in mind, for he has himself published one of the most valuable descriptions of the ontogenetic development of the ascidian neural gland.[2]

The whole question of the homologies of the neural gland of tunicates is an exceedingly complicated and difficult one. It is by no means certain even that this gland is represented in the vertebrates by either of the two portions of that compound structure which is called the hypophysis cerebri, yet this homology proposed by Julin is comparatively simple, since the ascidian gland and one part of the vertebrate hypophysis are of neural origin. Willey's theory is much more startling, for it claims a genetic relationship between a portion of the central nervous system in ascidians (the neural gland) and a portion of the cœlom (the proboscis canals) in Enteropneusta. Yet the only foundation for the theory which I am able to find in his paper

[1] Willey regards the condition with two proboscis pores as more primitive than that with one.

[2] Several further objections to the proposed homology might be urged, but it seems hardly wise to treat the theory too seriously.

is the fact that in certain adult individuals of one species of Ptychodera he finds sometimes one, sometimes the other, of the two proboscis pores opening "into the base of the medullary tube somewhat behind the anterior neuropore." In younger specimens he finds the single median proboscis pore opening somewhat in front of the "anterior neuropore." The occasional peculiarity he has observed in *Ptychodera carnosa* seems a rather narrow apex on which to found so broad a pyramid of theory.

Willey's third proposition as to regional pores and nephric tubules is best presented by copying his own table, which is self-interpreting, with the one explanation that the organs mentioned in the right-hand column are not intended to be represented as serially homologous with those in the preceding columns.

Group.	Archimeric System.			Essential Organs of Excretion.
Ideal . . .	Protomeric pores	Mesomeric pores	Opisthomeric pores	Regional pore canals
Enteropneusta	Proboscis pores	Collar pores	Truncal pores (Spengelia)	Glomerulus
Cephalochorda	Præoral pit and Olfactory pit	Hatschek's nephridium	Lankester's brown funnels	Boveri's nephric tubules
Urochorda	Neuro-hypophysis (in part)[1]			Renal vesicles: Organ of Bojanus (Molgulidæ)
Vertebrata	Hypophysis (in part)[1]			Pronephros Mesonephros Metanephros

In some of the Ptychoderidæ Willey found that the collar nerve tube does not completely separate from the dorsal epidermis from which it arose, but that there are partially hollow connecting strands running from the nerve tube to the mid-dorsal line of the collar. The more or less interrupted lumina of these

[1] In part because cœlomic element is wanting.

hollow strands may in certain cases connect with the lumen of the central nerve tube. These hollow strands or "roots of the Ptychoderidæ," Willey says, "are genetically related to the epiphysial complex of Craniota; in the crucial nuchal region of the Enteropneusta are, therefore, to be found not the actual but the nearest possible approximation to the actual primordia of the . . . epiphysis cerebri of Craniota." Of course this *may be* true, yet it seems questionable if it be "profitable for doctrine."

Willey's fifth proposition he states as follows: "Just as the medullary tube of the collar is admittedly an invaginated portion of the dorsal nerve trunk,[1] so the medullary folds which arise and fuse to form the medullary tube are to be regarded as specializations of the anterior portion of the pleural folds which are retained in the Ptychoderidæ as the genital pleuræ." "The genital folds of Enteropneusta, the atrial folds of Amphioxus, and the medullary folds of Vertebrata belong to the system of pleural folds of the body wall, and are differentiated from a common primordium." In this connection it may be well to remember that Amphioxus has both medullary folds and atrial folds, and that there is no apparent relation between them.

Willey's sixth proposition refers to a recession of the "posterior neuropore" until it reaches and becomes associated with the blastopore ("primitive anus") to form the neurenteric canal. I do not, however, clearly understand the terms he uses.

Dr. Willey next discusses briefly the different regions of pseudo-chondroid tissue, *i.e.*, "stomochord, pygochord, and pleurochords."

Willey points out that the tongue bars of the gill region of the Enteropneusta "are not (ontogenetically) secondary, as they are in Amphioxus," and that "by their development, size, and

[1] *Cf.* Morgan (*Journal of Morphology*, vol. ix, 1894, p. 74). "We see in Balanoglossus that the *invaginated* dorsal nerve cord can correspond only to the anterior end of the nerve cord of Amphioxus, and that the *superficial* dorsal nerve path, stretching through the gill region, thence to the end of the body, must be the homologue of the remainder of the nerve cord of Amphioxus."

vascularity, they obviously constitute collectively the essential organs of respiration. In Amphioxus the functional importance of the tongue bars is greatly diminished ; they are smaller in size and lower in vascularity than the primary bars, and their development is secondary."

In certain of the Enteropneusta the ventral edges of the gill slits are swollen on the pharyngeal surface, and these thickened areas of the walls of the successive gill slits are continuous, forming a pair of lateral ciliated pharyngeal ridges. These "arch round in front to unite in the epibranchial band," and represent the endostyle of Amphioxus and the Tunicata.

In one part of his memoir Dr. Willey describes certain phenomena of regeneration in *Ptychodera flava*, summarizing them as follows :

(1) "When regeneration occurs in the region of the genital pleuræ the collar is regenerated from the pleuræ.

(2) "The collar nerve tube is formed by the fusion of true medullary folds which are differentiated from the pleural folds.

(3) "The zones of the collar are differentiated from the annulations of the body wall.

(4) "In regenerating individuals the right and left proboscis pores are approximately equal.

(5) "In regenerating individuals the lumen of the stomochord[1] is at first entire."

I trust the absence of comment in this review upon some of the proposed theories will not be interpreted as indicating my acceptance of these theories. The paper is noteworthy for the boldness and confidence with which it sets forth startling propositions.

THE WOMAN'S COLLEGE OF BALTIMORE,
January 9, 1900.

[1] Notochord of Bateson.

SYNOPSES OF NORTH-AMERICAN INVERTEBRATES.

VII. The Cyclometopous or Cancroid Crabs of North America.

MARY J. RATHBUN.

In the Cyclometopa the carapace is usually broader than long, regularly arched in front, and not rostrate; the epistome is short and transverse; the outer maxillipeds have the fifth joint articulated at the inner front angle of the fourth; there are nine pairs of branchiæ, their efferent channels opening at the sides of the endostome or palate; and the genital organs of the male are inserted at the bases of the last pair of trunk legs.

This tribe contains many well-known crabs, including all the large edible species of the United States — the common "blue crab," or Callinectes, of our eastern coast, the stone crab (Menippe) of the Southern States, and the large *Cancer magister*, or common crab, of the Pacific coast.

The Cyclometopa, as represented in North America, may conveniently be subdivided into three families: first the Cancridæ, containing the genus Cancer with eleven species, some of which attain a large size and which frequent rocky and sandy bottoms, and the genera Telmessus and Erimacrus, hairy crabs inhabiting Bering Sea and the North Pacific and furnishing food for fur seals.

The remainder of the crabs of cancroid shape, that is, transversely oval or hexagonal and without projecting spines or natatory feet, are included in the family Pilumnidæ, many of which are small species inhabiting muddy places or living under stones or in crevices of rocks or sponges.

The family Portunidæ, or the swimming crabs, have, with one exception, the last pair of legs developed into a swimming

paddle. They include the widespread pelagic *Portunus sayi*, the "lady crab," or "calico crab" (*Ovalipes ocellatus*), and the edible Callinectes.

In the key which follows, the same terms are employed to indicate geographical distribution as in Professor Kingsley's keys to the Macrura, with two additions. Although the species of the southern half of Florida are excluded from the key as belonging properly to the West Indian fauna, those of the remainder of the Gulf coast are included. It has also seemed advisable to indicate by the letters *CH* those species whose northern limit is Cape Hatteras. The characters used are as follows:

A Alaska south.
P Puget Sound to San Francisco.
D Monterey to San Diego.
N Atlantic coast south to Cape Cod.
M Cape Cod to North Carolina.
S South Carolina to Florida.
G Gulf of Mexico.
CH Cape Hatteras, northern limit.

The bathymetrical limit is 100 fathoms.

KEY TO THE FAMILIES OF THE TRIBE CYCLOMETOPA.

A. Antennulæ folded longitudinally. Outer maxillipeds long, overlapping the epistome . . . . CANCRIDÆ Latreille, Alcock

A′. Antennulæ folded transversely or obliquely transversely. Outer maxillipeds usually not overlapping the epistome.

B. Last pair of legs not modified for swimming
PILUMNIDÆ Leach = XANTHIDÆ Alcock

B′. Last pair of legs usually modified for swimming, with the last two joints compressed, very broad and paddle-like. Carapace widest at the last antero-lateral marginal spine. Usually from 5 to 9 antero-lateral spines or teeth . . . PORTUNIDÆ Leach, Miers

KEY TO THE GENERA OF THE FAMILY CANCRIDÆ.

A. Buccal cavity completely closed by the outer maxillipeds . . Cancer

A′. Buccal cavity not completely closed by the outer maxillipeds.

B. Carapace broader than long, pentagonal . . . . . Telmessus

B′. Carapace longer than broad, suboval . . . . . Erimacrus

The Species of Cancridæ.

Genus Cancer Linnæus.

Key to Species.

A. Ambulatory legs very broad and flat, especially those of the last pair
C. magister Dana *APD*

A′. Ambulatory legs of moderate width.

B. Fronto-orbital width small, about one-fifth width of carapace. Front strongly advanced beyond outer orbital angles
C. productus Randall *APD*

B′. Fronto-orbital width more than one-fifth width of carapace. Front not greatly advanced beyond outer orbital angles.

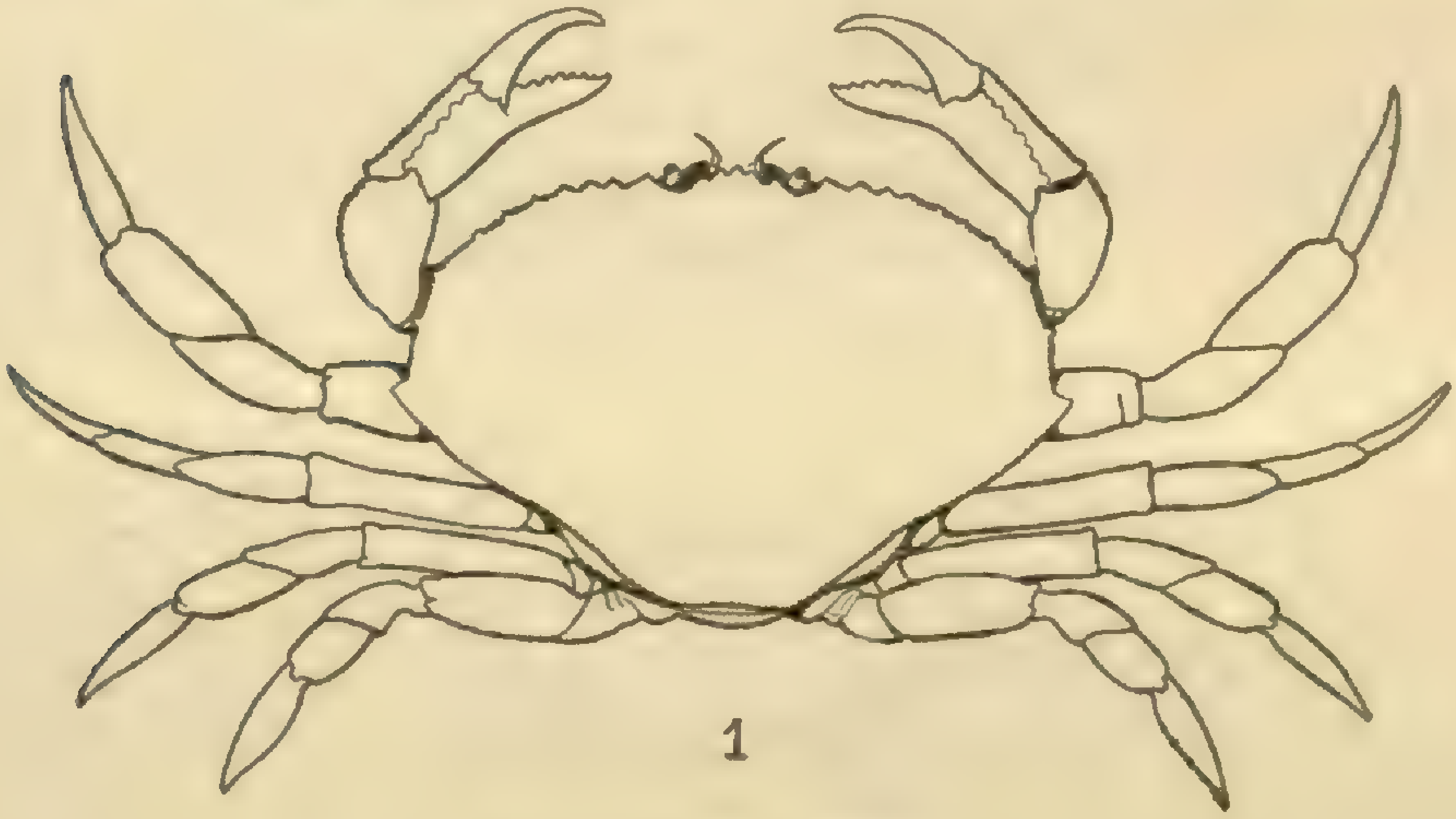

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Fig. 1. — *Cancer magister.*

C. Color on the fingers extending from the tip not more than half the length of the fingers.

D. Carpus of cheliped with two spines at inner angle, one below the other.

E. Antero-lateral teeth shallow, projecting little from the carapace. Carapace very slightly areolated
C. gracilis Dana *APD*

E′. Antero-lateral teeth strong, projecting well out from the carapace.

F. Fronto-orbital width one-third the width of the carapace. Carapace strongly areolated
C. gibbosulus (de Haan) *APD*

F′. Fronto-orbital width nearly half the width of the carapace. Carapace slightly areolated
C. jordani Rathbun, sp. nov.,[1] *D*

[1] Type, U. S. Nat. Mus. No. 22868, Monterey Bay, Harold Heath, collector. The new species noticed in this paper will be described in full in the *Proceedings of the United States National Museum*.

D′. Carpus of chelipeds with one spine at inner angle.

E. Antero-lateral teeth with dentate or spinulous margins.

F. Crests on hand feeble, granulate — *C. anthonyi* Rathbun *D*

F′. Crests on hand strong, the upper ones spinulous — *C. borealis* Stimpson *NM*

E′. Antero-lateral teeth with margins simply granulate — *C. irroratus* Say *NMS*

C′. Color on the fingers extending from the tip more than half the length of the fingers.

D. Fronto-orbital width one-third the width of the carapace — *C. antennarius* Stimpson *APD*

D′. Fronto-orbital width nearly one-half the width of the carapace. Carapace strongly areolated.

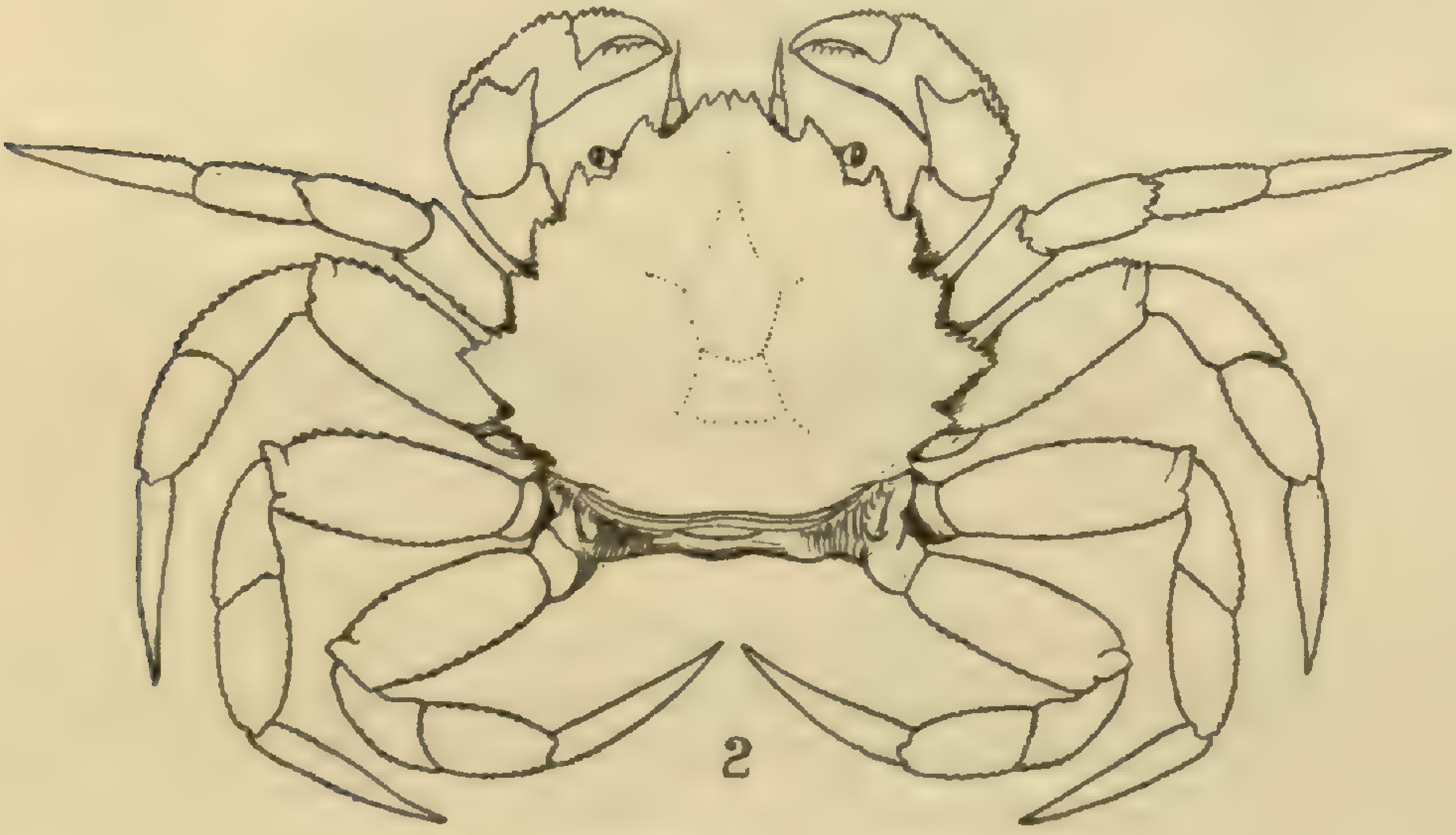

Fig. 2. — *Telmessus cheiragonus.*

E. Front truncate. Movable finger almost entirely dark-colored . . *C. oregonensis* (Miers) *APD*

E′. Front not truncate. Movable finger not more than two-thirds dark-colored . *C. amphiœtus* Rathbun *D*

Genus Telmessus White . . . . *T. cheiragonus* (Tilesius) *AP*

Genus Erimacrus Benedict . . . . *E. isenbeckii* (Brandt) *A*

Key to the Genera of the Family Pilumnidæ.

A. The ridges that define the efferent branchial channels, if present, are low, and are confined to the posterior part of the endostome, never reaching to the anterior boundary of the buccal cavern.

B. Fronto-orbital border less than half the greatest width of the carapace.

C. Antero-lateral margin continued to the angle of the buccal cavity. Carapace eroded . . . . Glyptoxanthus

C′. Antero-lateral margin ending at the orbit.

D. A deep notch in the anterior border of the merus of the external maxillipeds. Carapace nodose . . Daira

D′. No deep notch in the anterior border of the merus of the external maxillipeds. Carapace not nodose Cycloxanthops

B′. Fronto-orbital border half or more than half the greatest width of the carapace.

C. Chelipeds with a circular cavity on the anterior margin between the carpus and manus . . . . Carpoporus

C′. Chelipeds without a circular cavity on the anterior margin.

D. Carpal joints of ambulatory legs armed above with a horned or lunate crest . . . . Heteractæa

D′. Carpal joints of ambulatory legs not armed with a horned crest.

E. Carapace transversely oval.

F. Ambulatory legs spiny or granular on the upper border . . . . Xanthias

F′. Ambulatory legs not spiny nor granular on the upper border.

G. Four or more well-marked antero-lateral teeth, excluding the orbital Leptodius

G′. Four antero-lateral teeth (besides the orbital), the first of which is low and more or less fused with the orbital Eurypanopeus

E′. Carapace more or less hexagonal or subquadrate.

F. Carpal and propodal joints of ambulatory legs more or less cristate . . . Lophopanopeus

F′. Carpal and propodal joints of ambulatory legs not cristate.

G. Ambulatory legs spinulous. Micropanope

G′. Ambulatory legs not spinulous.

H. Three antero-lateral teeth besides the orbital, the second normal tooth, or that next the orbital, being obsolete Glyptoplax

H′. Four antero-lateral teeth besides the orbital, the second normal tooth, or that next the orbital, being sometimes partially united with the orbital, but never obsolete.

J. Terminal segment of abdomen of male oblong. Carapace subquadrate, narrow (length about three-fourths width), approaching the Catometopa. Prominent transverse dorsal ridges Rhithropanopeus

J′. Terminal segment of abdomen of male subtriangular. Carapace when subquadrate, wider than the preceding.

K. Front arcuate. Carapace hexagonal. Neopanope

K′. Front with truncate or sinuous lobes.

L. Front very narrow and advanced. Postero-lateral margins strongly converging. Carapace hexagonal Hexapanopeus

L′. Front of moderate width. Postero-lateral margins not strongly converging. Carapace subquadrate Eupanopeus

A′. The ridges that define the efferent branchial channels extend to the anterior boundary of the buccal cavern and are often very strong.

B. Fronto-orbital border just about half or less than half the greatest breadth of the carapace, which is broad and transversely oval.

C. Antero-lateral margin much shorter than the postero-lateral. Front with two simple lobes . . . . Eurytium

C′. Antero-lateral and postero-lateral margins subequal. Front with two lobulate lobes . . . . Menippe

B′. Fronto-orbital border much more than half the greatest breadth of the carapace.

C. Carapace nodose . . . . Lobopilumnus

C′. Carapace not nodose, but often granulate or spinous, and usually hairy . . . . Pilumnus

The Species of Pilumnidæ.

Genus Glyptoxanthus A. Milne Edwards . . . *G. erosus* (Stimpson) *G*
Genus Daira de Haan . . . . *D. americana* Stimpson[1] *D*
Genus Cycloxanthops Rathbun . . *C. novemdentatus* (Lockington)[2] *D*
=*C. californiensis* Rathbun
Genus Carpoporus Stimpson . . . *C. papulosus* Stimpson *M(CH)G*
Genus Heteractæa Lockington *H. lunata* (Milne Edwards and Lucas) *D*
Genus Xanthias Rathbun . . . . *X. taylori* (Stimpson) *D*
Genus Leptodius A. Milne Edwards *L. agassizii* A. Milne Edwards *M(CH)G*
Genus Eurypanopeus A. Milne Edwards . . *E. depressus* (Smith) *MSG*

Genus Lophopanopeus Rathbun.

Key to Species.

A. Upper margin of meral joints of ambulatory legs not spinulous.
- *B*. Hands smooth, without lobe or tooth on upper margin *L. bellus* (Stimpson) *APD*
- *B′*. Hands with one or more lobes or teeth on upper margin.
  - *C*. Carpus of cheliped smooth or nearly so.
    - *D*. Color of pollex running far back on hand *L. frontalis* Rathbun *D*
    - *D′*. Color of pollex not running back on hand *L. heathii* Rathbun, sp. nov.,[3] *D*
  - *C′*. Carpus of cheliped very rough.
    - *D*. Carpal joints of ambulatory legs strongly bilobed.
      - *E*. Carpus of cheliped covered with reticulating ridges enclosing pits of irregular shape *L. leucomanus* (Lockington) *D*
      - *E′*. Carpus of chelipeds covered with tubercles *L. diegensis* Rathbun, sp. nov.,[4] *D*
    - *D′*. Carpal joints of ambulatory legs slightly bilobed *L. lockingtoni* Rathbun, sp. nov.,[5] *D*

[1] California, on the authority of A. Milne Edwards.

[2] Mr. S. J. Holmes has compared specimens (not types) determined by Lockington as *Xantho novemdentatus*, with *C. californiensis*, and pronounces them the same. If the species are identical, Lockington's measurements of his type must be erroneous.

[3] Type, U. S. Nat. Mus. No. 22870, Monterey Bay, Harold Heath, collector.

[4] Type, U. S. Nat. Mus. No. 4281, San Diego, 10 fathoms, H. Hemphill, collector.

[5] Type, U. S. Nat. Mus. No. 19973, San Diego Bay, Steamer *Albatross*, collector. *Xanthodes latimanus* Lockington is probably a Lophopanopeus, but is not determinable with certainty.

A'. Upper margin of meral joints of ambulatory legs spinulous
L. distinctus Rathbun *G*

Genus Micropanope Stimpson.

Key to Species.

A. Second normal tooth of the antero-lateral margin absent
M. sculptipes Stimpson *SG*

A'. Second normal tooth of the antero-lateral margin present
M. xanthiformis (A. Milne Edwards) *M(CH)*

Genus Glyptoplax Smith.

Key to Species.

A. Last tooth of lateral margin small but well marked. Median lobe of the upper orbital margin strongly arcuate
G. smithii A. Milne Edwards *M(CH)G*

A'. Last tooth of lateral margin rudimentary. Median lobe of the upper orbital margin subtruncate . . *G. pusilla* (A. Milne Edwards) *G*

Genus Rhithropanopeus Rathbun . . . . *R. harrisii* (Gould) *NMSG*

Genus Neopanope A. Milne Edwards.

Key to Species.

A. Dactylus of larger hand with a large basal tooth
N. packardii (Kingsley) *G*

A'. Dactylus of larger hand without a large basal tooth.

B. Fingers white or light horn-color. Antero-lateral teeth sharp and much produced . . . . *N. texana* (Stimpson) *SG*

B'. Fingers black or dark-colored in the males. Antero-lateral teeth blunter and less produced . . *N. texana sayi* (Smith) *MS*

Genus Hexapanopeus Rathbun
H. angustifrons (Benedict and Rathbun) *MSG*

Genus Eupanopeus Rathbun.

Key to Species.

A. Carpus of cheliped with a groove parallel with its distal margin. Color of immovable finger not extending beyond the line of color on the movable finger . . . . *E. occidentalis* (Saussure) *S*

A'. Carpus of cheliped without groove. Color of immovable finger extending beyond the line of color on the movable finger
E. herbstii (Milne Edwards) *MSG*

Genus Eurytium Stimpson . . . . *E. limosum* (Say) *MS*

Genus Menippe de Haan.

Key to Species.

A. Surface of carapace almost smooth. Antero-lateral teeth or lobes shallow or little projecting . . *M. mercenaria* (Say) *M(CH)SG*

A'. Surface of carapace anteriorly nodose. Antero-lateral teeth strong, projecting well out from the carapace . *M. nodifrons* Stimpson *S*

Genus Lobopilumnus A. Milne Edwards . . . *L. agassizii* Stimpson *G*

Genus Pilumnus Leach.

Key to Species.

A. Carapace concealed by a short, thick pubescence, which, when removed, discloses tubercles on the gastric and hepatic regions *P. pannosus* Rathbun *G*

A'. Carapace, when covered by a short, thick pubescence, not having the gastric region tuberculate.

B. Superior orbital border with one or few long spines.

C. Superhepatic region unarmed *P. spinohirsutus* (Lockington) *D*

C'. Superhepatic region armed with spines or spinules *P. sayi* Rathbun *M(CH)SG*

B'. Superior orbital border either entire or armed with denticles or spinules.

C. Outer surface of smaller hand only partially covered with tubercles or spines . . . . . . *P. lacteus* Stimpson *G*

C'. Outer surface of smaller hand entirely covered with tubercles or spines . . . . *P. floridanus* Stimpson *G*

Key to the Genera of the Family Portunidæ.

A. Last pair of legs broad, modified into swimming paddles.

B. Carapace decidedly transverse; antero-lateral margins cut into nine teeth.

C. Movable portion of the antenna excluded from the orbital cavity by a prolongation of the basal joint of the antenna Charybdella

C'. Movable portion of the antenna not excluded from the orbit.

D. No longitudinal ridge on the palate . . . . Arenæus

D'. A longitudinal ridge on the palate.

E. Abdomen of male ⊥-shaped . . . . Callinectes

E'. Abdomen of male triangular . . . . . Portunus

B'. Carapace not very broad; antero-lateral margins cut into five teeth.

C. Last tooth of antero-lateral margin developed into a spine, longer than the other teeth or spines . . . Bathynectes

C'. All antero-lateral teeth similar . . . . Ovalipes

A'. Last pair of legs narrow, with dactylus lanceolate . . . Carcinides

The Species of Portunidæ.

Genus Charybdella Rathbun . . . . *C. rubra* (Lamarck) *S*

Genus Arenæus Dana . . . . *A. cribrarius* (Lamarck) *MSG*

Genus Callinectes Stimpson.

Key to Species.

A. Front with four intraorbital teeth.

B. Median pair of frontal teeth without an accessory tooth *C. sapidus* Rathbun *NMSG*

B'. Median pair of frontal teeth, each with an accessory tooth on its inner margin . . . . . *C. sapidus acutidens* Rathbun *SG*

A'. Front with six intraorbital teeth.

B. Intramedial region broad, its anterior width about three times its length. Posterior margin of antero-lateral teeth longer than the anterior . . . . *C. ornatus* Ordway *SG*

B'. Intramedial region narrow, its anterior width about twice its length. Second to sixth antero-lateral teeth equilateral *C. danæ* Smith *SG*

Genus Portunus Fabricius.

Key to Species.

A. Carapace wide; antero-lateral margin the arc of a circle with long radius, whose center is near the posterior margin of the carapace Subgenus Portunus = Neptunus de Haan

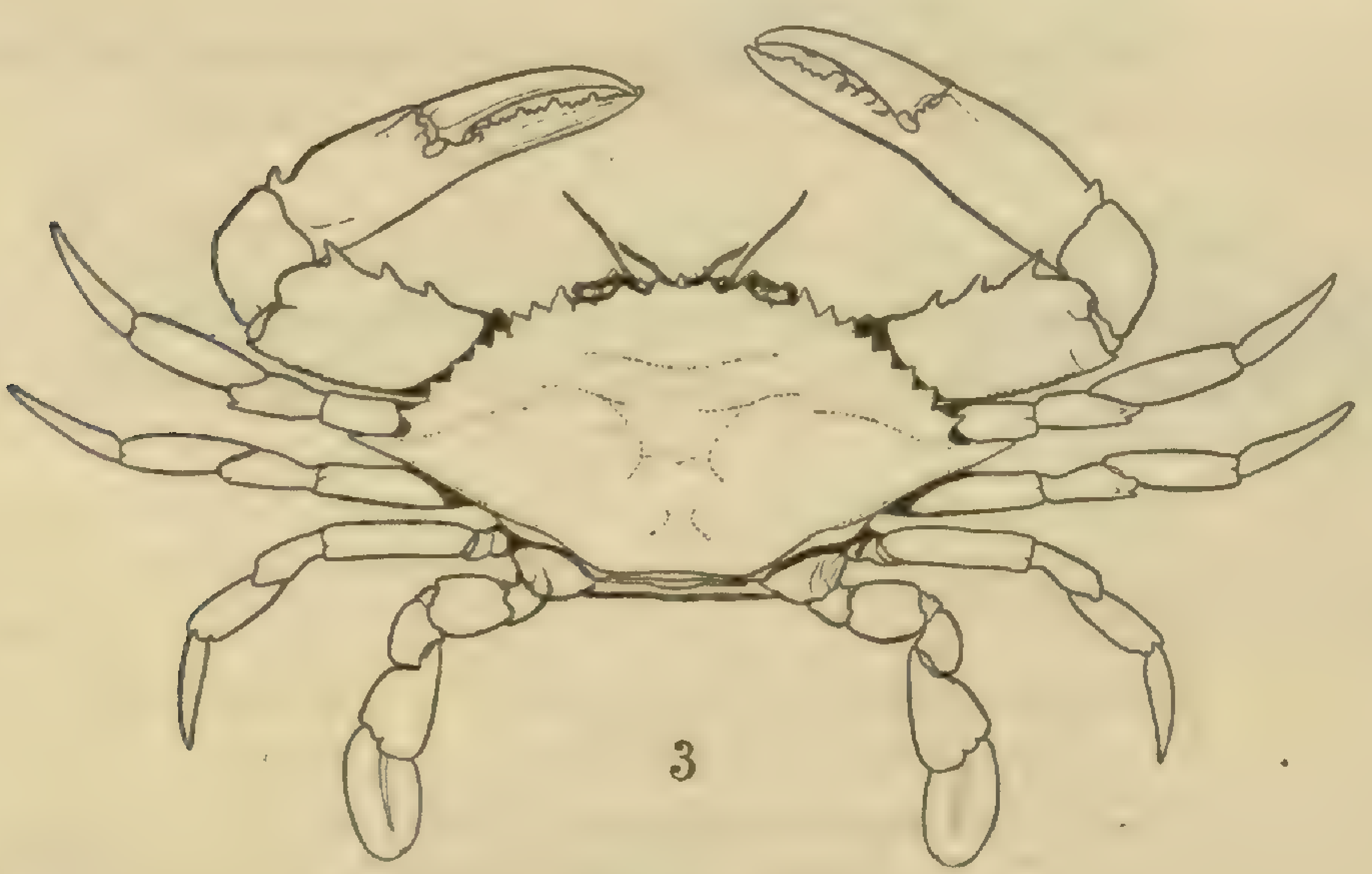

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FIG. 3. — *Callinectes sapidus.*

B. First eight lateral spines or teeth subequal.

C. Front with six intraorbital teeth *P. sayi* (Gibbes) *NMSG*

C'. Front with eight intraorbital teeth *P. gibbesii* (Stimpson) *MSG*

B'. Second, fourth, and sixth lateral teeth or spines smaller than the others . . . . *P. xantusii* (Stimpson) *PD*

A'. Carapace narrow; antero-lateral margin the arc of a circle with short radius, whose center is near the center of the cardiac region

Subgenus Achelous de Haan (including Hellenus and Amphitrite de Haan).

B. Carapace with rounding posterior corners.

C. Posterior of the lateral spines of the carapace exceeding the other spines or teeth but little if at all.

D. Three spines on manus *P. anceps* (Saussure) *M(CH)*

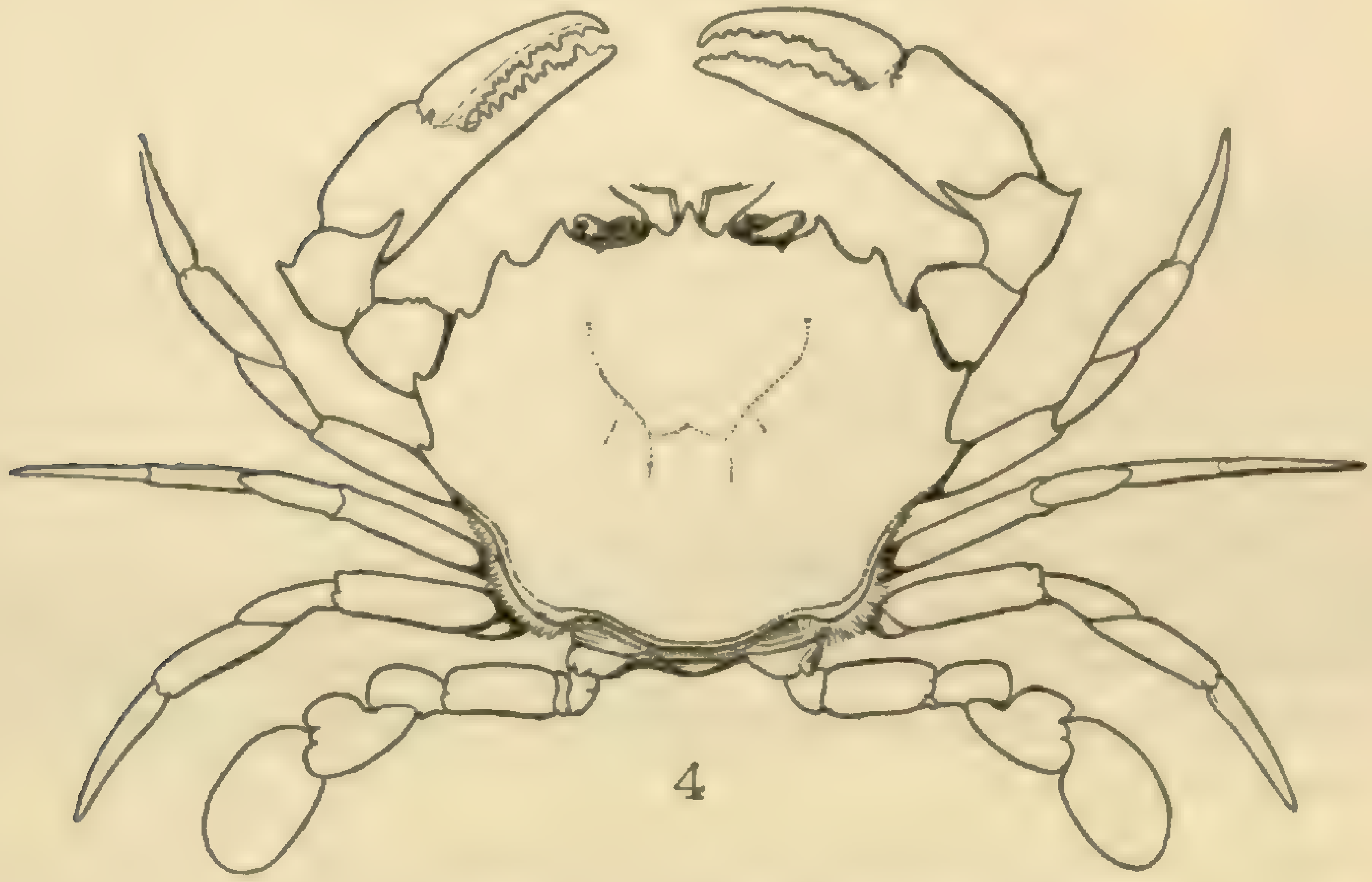

FIG. 4. — *Ovalipes ocellatus.*

D'. Two spines on manus.

E. Superior outer surface of manus smooth, iridescent *P. ordwayi* (Stimpson) *G*

E'. Superior outer surface of manus with a longitudinal, tuberculated ridge.

FIG. 5. — *Carcinides mænas.*

F. Front with eight intraorbital teeth *P. spinimanus* (Latreille) *MSG*

F'. Front with six intraorbital teeth *P. depressifrons* (Stimpson) *S*

C'. Posterior of the lateral spines of the carapace much longer than the other lateral spines or teeth
P. sebæ (Milne Edwards) *M(CH)*

B'. Carapace with sharp posterior angles
P. spinicarpus (Stimpson) *M(CH)G*

Genus Bathynectes Stimpson . . . . *B. superba* (Costa) *M*
Genus Ovalipes Rathbun . . . . *O. ocellatus* (Herbst) *NMSG*
Genus Carcinides Rathbun . . . . *C. mænas* (Linnæus) *M*

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REVIEWS OF RECENT LITERATURE.

ANTHROPOLOGY.

Anthropological Notes. — The rate of erosion of the gorge of Niagara has been variously estimated, and the length of time that has elapsed since the river began its cutting has been shortened or lengthened to correspond. Owing to the problems connected with the relations of early man in America to the glacial epoch, the discussion of the value of Niagara as a chronometer, in No. 4, Vol. XXXI, of the *Bulletin of the American Geographical Society*, will be of interest to anthropologists. Professor Tarr summarizes the results of the many investigations in the following words: "Gilbert says that the problem of the age of Niagara cannot 'be solved by a few figures on a slate, nor yet by the writing of many essays.' To this every one who has given attention to the problem must assent. The longer the study, the more complex the problem appears, and we are bound to conclude that Niagara is not a good chronometer. Until more evidence has been obtained concerning the length of the overflow at Nipissing Pass, which some believe to have been long, others short, we are bound to remain in doubt whether the age is from 5000 to 10,000 years or from 30,000 to 50,000 years."

In the *American Anthropologist* for October, 1899, appears a second paper by Mr. W. H. Holmes upon "Preliminary Revision of the Evidence relating to Auriferous Gravel Man in California." Mr. Holmes devotes his attention chiefly to the Calaveras skull, the most important of the human remains reported from the auriferous gravels. He regards this supposed Tertiary relic as quite modern, probably the skull of a Digger Indian. Notwithstanding his masterly summing up of the evidence for the negative, the case cannot be considered closed until the facts presented by Becker, Wright, and King have been explained. Mr. Holmes is unjust in his intimation that the possessors of the skull have been neglectful of their obligation in not taking further steps to prove its authenticity during the thirty-three years that it has been in Cambridge. Professor Whitney adequately described the skull in his volume on *The Auriferous Gravels of the Sierra Nevada of California.* It was always accessible to any one

wishing to examine it. Further evidence was obtainable only in the locality whence it came. No opportunity to seek such evidence has yet occurred during the short period in which the skull has been in the possession of the Peabody Museum.

The sixth summer meeting of "The American Association to Promote the Teaching of Speech to the Deaf" was held at the Clarke School for the Deaf, Northampton, Mass., in June, 1899. In his presidential address Dr. Alexander Graham Bell reviewed the history of the association from the time of its foundation in 1890. A condensed account was also given of the present condition of instruction in speech-teaching in the United States. Only a few years ago silent methods of instruction of deaf-mutes were everywhere in vogue; now speech is used as a means of instruction with the majority of such pupils (53.1 per cent), and the total number taught speech and speech-reading amounts to 6460, or 61.4 per cent of the whole. There is a steady increase in the percentage of speech-teaching, and Dr. Bell believes that the time is not far distant when speech will be taught to every deaf child in America. In a reprint from *The Association Review*, Dr. Bell adds a number of tables of statistics compiled from the *American Annals of the Deaf*. These show the number of schools, pupils, teachers, and give lists of the schools, with their location, official names, directors, etc.

F. R.

GENERAL BIOLOGY.

A Study of Heredity among the Deaf.[1] — We are indebted to Professor Edward Allen Fay for an important contribution to the data of heredity. The collection of the large mass of material and publication of the expensive tables were made possible by a liberal use of the funds of the Volta Bureau, an institution endowed by Dr. Alexander Graham Bell "for the increase and diffusion of knowledge relating to the deaf."

The inquiry was begun in 1889. Circulars containing questions to be answered were distributed widely among heads of schools for the deaf, the deaf themselves, and their relatives and friends. Facts were gathered also from journals for the deaf, school reports, and

[1] Fay, E. A. *Marriages of the Deaf in America*. Washington, The Volta Bureau, 1898 (1899). vii, 527 pp., 8vo.

returns of census enumerators. The result was that more or less complete returns were received of 4471 marriages in which one or both of the partners were deaf. After deducting marriages of less than a year's standing, the total number of marriages of which the results in regard to offspring are reported is 3078, and number of children is 6782. These numbers are large enough to promise fairly trustworthy results.

The first third of the book is taken up with a discussion of the results, and the rest is devoted to a tabular statement giving the details in regard to each marriage. This is followed by an index.

Within the space of a review one cannot do more than refer to some of the conclusions which are of especial interest. Passing over the statistics in regard to the relative fertility of the deaf and the hearing, the proportion of deaf children in the total marriages of the deaf, etc., we come to a comparison between the proportion of deaf children born when both parents are deaf and the number when one parent only is in this condition, and we find the surprising result that in the first case there are only 8.458 per cent of deaf children, while in the second there is a considerably larger percentage, namely, 9.856. This would seem to upset all one's ideas of heredity. But the anomaly is explained to a great extent when we take into consideration the nature of the deafness, whether congenital or acquired, the ancestry of the parents, and their relationship to one another.

The author calls attention to the fact that deafness may be due to a number of causes, such as various infectious diseases, malformation of various auditory organs, and the like. It is not deafness as such that is inherited, but some tendency to disease, or some abnormal habit of growth. This makes it difficult to distinguish deafness which is congenital and that which is adventitious, even when the patient can be examined; and it is still more difficult to make the distinction from the reports of cases such as were used in this inquiry. Therefore it is not a matter of surprise that the author fails to give a good definition of the two kinds of deafness.

Notwithstanding this uncertainty of definition, the results as to the relative frequency of deafness in children of congenitally deaf parents and parents adventitiously deaf are decidedly interesting. Thus it is found that where both parents are congenitally deaf the percentage of deaf children is 25.931; where one parent is congenitally deaf and the other adventitiously deaf it is 6.538; while where both parents are adventitiously deaf it is but 2.326. But where one parent is congenitally deaf and the other hearing 11.932 per cent of the children

are deaf; and when one parent is adventitiously deaf and the other hearing the percentage is 2.244. Here appears again the surprisingly large number of deaf children of hearing parents. But it is very evident that adventitious deafness is transmitted much less readily than congenital deafness. Indeed, it cannot be proven by these statistics that the former is ever inherited, because of the unknown error in the classification of the two varieties of deafness.

The statistics show that the presence of deafness among the relatives of the parents increases very largely the chances that deaf children will be produced, and this is, of course, what would be expected. Taking the cases where both parents have deaf relatives (not including descendants), the percentage of deaf children where both parents are congenitally deaf is raised to 30.303; where both parents are deaf but only one congenitally deaf the percentage is 10.903; where one parent was congenitally deaf and the other hearing there is again a large percentage, 24.286; and where both partners are adventitiously deaf there are 9.649 per cent of deaf children. Now, taking the cases where only one parent had deaf relatives, the percentages are 20.0, 5.536, 11.864, and 2.801, respectively. Finally, where neither partner had deaf relatives the figures are 4.167, 1.515, 15.789, and 0.364. In this last series the first and third percentages represent one child and three children, respectively, and the third one would be much reduced if one doubtful case were discarded.

Over 45 per cent of the hearing parents whose family history is recorded had deaf relatives, while this is true of only about 32 per cent of the adventitiously deaf. This fact, taken in connection with the evidence as to the effect of history of deafness in the family of the parents in increasing the chances of deafness in the children, seems to explain to a great extent the large proportion of deaf children of hearing parents compared with those of the adventitiously deaf which appears in the general statistics. But even when the factor of family history is taken into account, as in the tables summarized in the preceding paragraph, there is still to be found a remarkably large proportion of deaf children of hearing parents. The author attempts to explain this on the ground of consanguinity. When both partners are deaf the largest percentage of deaf children is obtained from consanguineous marriages, 32.258 per cent; and in consanguineous marriages where one partner is deaf and the other hearing the percentage is nearly as large, 29.851. In cases of deafness, then, the peculiarity of the parents seems to be more strongly

inherited when they have a common ancestry. Now it is found that of the 3242 marriages where both partners were deaf only 12, or 0.370 per cent, were consanguineous; while of the 894 marriages where one partner was deaf and the other hearing 18, or 2.013 per cent, belonged to this class. The 20 deaf children born from the latter class of consanguineous marriages constitute 13.2 per cent of the total 151 deaf children born from marriages in which one of the partners was a hearing person; while the 10 deaf children from the former class of marriages constitute only 2.3 per cent of the total 429 deaf children having both parents deaf. It is difficult to see why consanguinity should so intensify hereditary characteristics; but if it does do so, then this large proportion of consanguineous marriages between the hearing and the deaf accounts to some extent for the large proportion of deaf children. How far this goes to explain the facts can only be determined mathematically; and this the author does not attempt.

It is to be regretted that the author did not inquire more particularly in regard to the condition of the parents of the deaf married persons. The parents were simply included in the general inquiry concerning "other relatives," with the result that on examining the Tabular Statement of Marriages one is disappointed to find that it is often impossible to tell whether the parents were hearing or unreported. If this point had been attended to, these statistics might have been expected to furnish an important confirmation, or the reverse, of Galton's law of filial regression. R. P. B.

Blatchley's "Gleanings from Nature." — Mr. Willis S. Blatchley, State Geologist of Indiana, has published in book form, under the head of *Gleanings from Nature*, a number of fragments of popular science contributed by him to the press of Indiana and to Appleton's *Popular Science Monthly.*

The essays are truthful rather than literary, and they give vivid touches of nature, the results of close and sympathetic observation.

The first essay discusses charmingly the harbingers of spring in Indiana — the maples, skunk cabbage, trillium, yellow-hammer, fox sparrow, and the birds and flowers that mark the end of winter. Other topics discussed are "Two Fops among the Fishes," "Snakes," "The Gnat Catcher," "The Old Canal," "The Iron Weed," "The Indiana Caves and their Inhabitants," "The Tamarack Swamp," "The Katydids," "The Winter Birds," and "How Animals and Plants spend the Winter."

The volume is well printed by the Nature Publishing Company, and very well illustrated, in part with original photographs.

This book can be highly commended for its honesty and directness of purpose. Its author stands on his own feet and neither poses nor gushes, and his work is worthy of its purpose. D. S. J.

ZOÖLOGY.

Artificial Production of Rhythmic Muscle Contractions. — Professor Loeb[1] has pointed out that certain solutions containing ions of sodium, chlorine, lithium, bromine, iodine, etc., may cause rhythmical contractions in muscle, and that solutions containing certain other ions, calcium, potassium, magnesium, barium, strontium, etc., check such contractions. It is supposed that the rhythmic contractions are the result of the combination of the particular ions with the muscle. The rhythmic action of the heart may be a natural example of this kind of action. G. H. P.

Evermann and Marsh on Fishes of Puerto Rico. — In the *Report of the United States Fish Commission* for 1899, Dr. Barton W. Evermann and Willard C. Marsh give an account of new species discovered by them in the late cruise of the *Fish Hawk* about the island of Puerto Rico under Dr. Evermann's direction. An elaborate account of these important investigations is in preparation. The present paper gives a preliminary account of three new genera of Blenniidæ — Gillias, allied to Tripterygion; Auchenistius, a Blenny, allied to Auchenopterus; and Coralliozetus, allied to Ophioblennius — and of twenty new species belonging to different families. These are: *Lycodontis jordani*, *Stolephorus gilberti*, *Stolephorus garmani*, *Prionodes baldwini*, *Calamus kendalli*, *Doratonotus decoris*, *Sicydium caguitæ*, *Gobius bayamonensis*, *Bollmannia boqueronensis*, *Microgobius meeki*, *Gillias jordani*, *Malacoctenus culebræ*, *Malacoctenus moorei*, *Malacottenus puertoricensis*, *Auchenistius stahli*, *Auchenopterus albicaudus*, *Auchenopterus rubescens*, *Auchenopterus cingulatus*, *Auchenopterus fajardo*, and *Coralliozetus cardonæ*. Most of these are small fishes of

[1] Loeb, J. Ueber Ionen welche rhythmische Zuckungen der Skelettmuskeln hervorrufen, *Festschrift zum 70. Geburtstage des Herrn Geheimrath Prof. Dr. A. Fick*, pp. 101–119. 1899.

the coral reefs and rock pools, localities in which the greater number of the yet unknown fishes of the tropics are likely to be found.

Evermann and Marsh are to be congratulated on the use of the correct name of the island of Puerto Rico, instead of the lazy corruption of Porto Rico. This is, we believe, the first government document of the United States in which the name is correctly spelled. The spelling Puerto Rico is, however, now officially adopted by the Government Board of Geographical Names.

D. S. J.

Tunicates of Pribilof Islands. — Part III of "The Fur Seals and Fur-Seal Islands of the North Pacific Ocean," published by the Government, contains an account by W. E. Ritter of the Tunicates of Pribilof. Eleven species are reported upon, ten of which are new to science.

Physiology of the Cephalopods. — An excellent résumé of our knowledge of the physiology of the cephalopods has been given by Victor Willem in the *Bulletin Scientifique de la France et de la Belgique*, Tome xxxi, pp. 31–54. The article is accompanied by an extensive bibliography.

Excretion in Mollusca. — Cuénot[1] has studied the function of excretion in mollusks by means of physiological injections, and attains results which modify some generally accepted views derived from anatomical and histological data. From the review of the literature on Mollusca one sees that the excretory function has been ascribed primarily to the nephridia (organs of Bojanus), then also to the pericardial glands of lamellibranchs, and finally without sufficient proof to the modified pericardial epithelium and to certain scattered liver cells.

The interior of any animal maintains a relatively constant composition, due to the presence of excretory cells which remove any excess of normal material or any abnormal, *i.e.*, excretory, substance which would poison the organism. The cell exercises, however, the choice among such substances, thus demonstrating the varied nature of the excretory cells. Introduced substances may (1) enter into the cycle of metabolic changes; (2) be attracted and precipitated in skeletal or yolk material; (3) undecomposed and unfixed, be collected by excretory cells, and thus impart color to the excretory organs. Certain

[1] Cuénot, L. L'excrétion chez les Mollusques, *Arch. de Biol.*, vol. xvi (1899), pp. 49–96, Pls. V, VI.

cells absorb some substances with avidity, but are totally indifferent to others.

Among the variable types of excretory cells two appear to be constant; the first absorbs indigo-carmine and refuses ammonium-carminate, while the second precisely reverses this action. Rarely excretory cells do both, but even then the one more freely than the other. These two types are associated with voluminous organs. The indigo kidneys produce urea, uric acid, and urates, while in carminate kidneys, thus far known, none of these substances are formed, though some non-indigo excretory cells contain urates. A tabular view of such organs for various groups of animals is reproduced on the opposite page, together with the products of each organ so far as known.

After discussion of the special technique employed, the author lists the various names by which the connective-tissue cells of mollusks are designated by different investigators, and distinguishes at least two types of such cells: (*a*) Reserve cells enclosing glycogen, and (*b*) excretory cells. In the terrestrial pulmonate gastropods the two functions are associated in a single cell, as in the liver cells of vertebrates.

In two groups of mollusks the nephridia, instead of being lined throughout their entire extent by a single type of excretory cell, present noteworthy differences: in Amphineura the reno-pericardial ducts of acid reaction eliminate actively carminate and litmus, while the rest of the nephridium, formed of different cells, and with alkaline reaction, eliminates indigo. In prosobranch gastropods the nephridia present a series of anatomical and physiological differentiations: Patella has two nephridia, very different in size but both eliminating equally indigo; in Trochus and Haliotus the larger right nephridium absorbs indigo alone; the left nephridium, very different in structure from the other, becomes faintly colored by carminate; finally, in monotocardic prosobranchs the single nephridium possesses two sorts of cells. The most numerous, non-ciliate, eliminate indigo; the others, ciliated, eliminate only carminate — the single nephridium being thus a physiological equivalent of the two nephridia in the Diotocardia (Trochus, etc.).

In the Amphineura, Solenoconcha, and Gastropoda there are, in the connective tissue, numbers of cells acid in reaction, of which the vacuoles actively absorb carminate and litmus. These scattered cells correspond physiologically to the pericardial glands of lamellibranchs and to the branchial heart of cephalopods which have the same power.

Mixed Kidney (Indigo and Carminate).

Vertebrates (Mammals, Bufo, etc.)	Convoluted tubules of kidney (alkaline)	Urea, uric acid, hippuric acid, etc.

Indigo Kidneys.

Tunicata (Phallusia, Molgula)	Closed kidney or blind vesicles	Uric acid
Sipunculida (*Phascolion strombi*)	Nephridium (acid)	Urate
Pulmonate gastropods (Oscanius)	Nephridium (acid)	Uric acid
Lamellibranchs	Nephridia (acid)	Urea, etc. Uric acid in Lutraria
Cephalopods	Nephridia	Uric acid in Sepia and *Octopus macropus*, Guanine or Xanthine in *O. vulgaris*
Crustacea decapoda	Labyrinth of antennal kidney and often vesicle (alkaline)	Leucomaine ?
Chilopoda (Lithobius, Scolopendra, Geophilus)	Malpighian tubes	Urates and uric acid
Diplopoda (Iulus)	Malpighian tubes	Sodic urate and calcic oxalate
Insecta	Malpighian tubes (alkaline)	Very often urates and uric acid

Carminate Kidneys.

Lamellibranchs (Pecten, Cardium)	Pericardial gland (acid)	Hippuric acid and sodic hippurate
Hirudinea	Convoluted portion of nephridia	Leucomaine ?
Crustacea decapoda	Vesicle of antennal kidney and branchial kidneys (acid)	Carcinuric acid
Scorpions	Liver	Guanin

The pericardial glands of lamellibranchs manifest three different types: intra-auricular masses in Pecten and Ostrea, external epithelium of the auricles (Mytilus), tubular glands opening virtually into the pericardium (Naiades). *Pecten maximus* affords a clear transition from the type of the lamellibranchs to that of the gastropods in that the connective tissue encloses, as in the latter, many isolated cells, which are massed in the wall of the auricles. The products in the cells of the pericardial glands of either type are engulfed by phagocytes, which transport them into lacunæ of the circulatory system. Some of these phagocytes reach the exterior through the branchial membrane; the others become fixed for life in the connective tissue.

In the cephalopods the excretory connective-tissue cells are accumulated exclusively in the wall of the branchial heart and of the appendix to that organ. In both organs, however, cells of a different character are present. In various gastropods (Pulmonata, Opisthobranchiata, and some Prosobranchiata, as Cyclostoma) the liver contains numbers of excretory cells which discharge their products into the intestine.

The collaboration of closed excretory cells and phagocytes to eliminate waste products, or at least to localize them in indifferent regions, is found in many groups: Oligochæta, Polychæta, Hirudinea, Sipunculida, Echinoderma. This method of excretion, which encumbers the tissue with masses of solid granules increasing with age, is evidently an imperfect function, and not improbably contributes to determine the death of the individual.

HENRY B. WARD.

The Heart of Anodonta. — The action of the heart of Anodonta has been fully studied by V. Willem.[1] Under ordinary circumstances the heart beats four to six times per minute. Contraction can be induced in an empty, quiet heart by injecting fluid into it, but an overfilling of the heart will retard the rate of contraction. The contraction of the ventricle drives the blood out under a pressure of one to three and a half centimeters of water. When the ventricle contracts, the auricles expand, and together these organs always fill the whole pericardial space. The contraction of the ventricle acts as a suction pump on the blood in the gills, drawing it into the auricles, and as a force pump on the blood in the arteries.

G. H. P.

[1] Willem, V. Recherches expérimentales sur la circulation sanguine chez l'Anadonte, *Mem. couron. Acad. Roy. des Sciences, des Lettres, et des Beaux-Artes de Belgique*, tome lvii, 28 pp., 2 pls., 1899.

Grafting and Regeneration in Hydromedusæ. — An interesting series of experiments on grafting and regeneration of Hydromedusæ has been carried out by C. W. Hargitt.[1] Small pieces of vigorous hydroid stems were held together in different positions by slivers of lead and were thus readily grafted. The bells of Gonionemus were emarginated so as to check their spontaneous movements and were then held together in pairs in various positions by being strung on bristles. As a result of these experiments, it was found that pieces of hydroid stems united with one another with great freedom either orally or aborally, and thus gave evidence of no polarity. The success of the experiments was quite independent of the sexes of the individuals from which the parts came. While pieces from closely allied species could be intergrafted, material representing different genera did not respond successfully. The experiments on the medusæ showed that though these animals regenerated and grafted freely, aboral grafts were never successful, the animal thereby showing a marked polarity.

G. H. P.

Regeneration in Grafted Tissue. — As is well known, the tail of one species of tadpole may be grafted on the body of another, and the two parts in time form an effective union. If the two species used have characteristically different kinds of pigment, the fate of the tissues thus brought together can be easily followed. The grafted ectoderm eventually covers only the tip of the developing tail, whereas the grafted mesoderm forms a considerable part of that organ, *i.e.*, at the beginning of grafting, the grafted tissues are separated from the stock tissues by a single transverse plane; later the plane of separation between grafted ectoderm and stock ectoderm is much posterior to that between the two kinds of mesoderm. Grafted tails when cut off regenerate, and the results of this process have been studied by T. H. Morgan.[2] If cut transversely, the cut surface from which regeneration will take place may exhibit a face of ectoderm from the stock and of mesoderm from the graft. The grafted tail may be cut obliquely, so that the cut surface will exhibit stock and graft ectoderm and graft mesoderm. In all these cases the regenerated tails are composed of cells easily referable to their sources, and it may be concluded that in regeneration from a region

[1] Hargitt, C. W. Experimental Studies upon Hydromedusæ, *Biological Bulletin*, vol. i, No. 1, pp. 37–51. October, 1899.

[2] Morgan, T. H. Regeneration of Tissue Composed of Parts of Two Species, *Biological Bulletin*, vol. i, No. 1, pp. 7–14. October, 1899.

where the cells have been derived from two different species, the specific characters of the cells remain distinct. G. H. P.

Note. — No. 3 of Vol. XV of the *Journal of Morphology* contains: "Studies on the Maturation, Fertilization, and Cleavage of Thalassema and Zirphæa," by B. B. Griffin; "On the Blood-Plates of the Human Blood, with Notes on the Erythrocytes of Amphiuma and Necturus," by G. Eisen; "The Phosphorescent Organs in the Toadfish, Porichthys notatus Girard," by C. W. Green; "On the Species Clinostomum heterostomum," by W. G. MacCallum; and "Mitosis in Noctiluca miliaris and its Bearing on the Nuclear Relations of the Protozoa and Metazoa," by G. N. Calkins.

GEOLOGY.

The Absaroka Range of the Rocky Mountains. — In a presidential address before the Geological Society of Washington,[1] and in the Absaroka Folio of the United States Geological Survey,[2] Mr. Arnold Hague has presented the results of many years' field work in a region that contains for vulcanologists problems of extraordinary interest. The Absaroka Range forms the mountain barrier to the east of the Yellowstone plateau, and is composed chiefly of horizontally stratified volcanic flows and breccias thrown out from vents, the location of which is not marked by conical volcanoes or even by any positive trace which would show that such volcanoes existed. Thicknesses from two thousand to five thousand feet of these lavas are deeply trenched by streams draining the eastern face of a range which marks in a sense the eastern escarpment of the great plateau that forms the Yellowstone Park. Early breccia and basalt sheets overlaid by late breccias and basalts make up the mass of these lavas. The only interruptions to their horizontal continuity are massive bodies of intrusive rock that invaded the lavas at two distinct periods.

Evidence of the age of the lavas is derived from the contained plant remains and from the old topographies which underlie them. The accumulation of volcanic material rests unconformably on rocks

[1] Hague, Arnold. Early Tertiary Volcanoes of the Absaroka Range.

[2] Folio No. 52, *Geologic Atlas of the United States*, Crandall and Ishawooa Quadrangles. Washington, 1899.

ranging from archæan to cretaceous, and is confined within ancient orogenic barriers on the north and south. Evidence of erosion during the piling up of the eruptive material is shown by canyon cross-sections, which give evidence of old depressions filled with silts and gravels; this indicates that considerable erosion took place at different times, with long interruptions in the local volcanic activity. Over one hundred and fifty species of plants have been identified from the tuffs and breccias, indicating a range in age from eocene to upper miocene. They are thus geologically older than the neocene rhyolites that form the greater portion of the Yellowstone Park.

The intrusive bodies occur as stocks and dikes; an earlier group, the "Sunlight" intrusives, is characterized by orthoclase and augite, and cuts the earlier breccias and basalts. The "Ishawooa" intrusives have broken into the later basalts as well as the earlier and are more siliceous rocks, ranging from diorite and diorite porphyry to true granitic types. Dikes are associated with all the larger bodies, sometimes being offshoots from them, in other cases cutting them or cut by them, and presenting a marvelous variety of structural and lithological types that afford material for the study of extensive gradation between coarse crystalline and glassy volcanic rocks. Many of the dikes of the Sunlight group are orthoclase basalts, collectively called by the name "absarokite," and are related to coarser monzonite stocks, which range in composition from quartzose augite syenites to coarse gabbros and diorites. These older intrusive bodies occur in three principal masses that form the points of a triangle, and about two of them the dikes show remarkable radiation. The Ishawooa intrusives extend for a distance of fifty miles into the Yellowstone Park, occurring as stocks, sheets, and dikes; they are usually conspicuous about the head waters of the eastern flowing streams, but do not form culminating summits, these being usually composed of the breccias or late basalts which overlie the intrusive rock. Dikes here, too, are abundant, but radiation is not especially marked, the greater masses having rather an axial trend in a northwesterly direction, as though injected through a common fissure, rather than as forming independent intrusions. The breccias in contact with the greater intrusive bodies are indurated to a distance sometimes of more than one-half mile. Coarse granites and diorites occur in both the intrusive series — a remarkable fact when we consider that the lavas invaded by them are of Tertiary age.

Mr. Hague concludes that variation in coarseness of crystallization is not dependent upon pressure, but is far more affected by the rate of cooling. He agrees with Professor Iddings in the belief that, for the same stock and its complex of dikes, variations in composition and structure are due to varying conditions of crystallization from a single molten magma. Hague, however, differs from Iddings in his conception of the significance of the apparent radiation of dikes about the diorite and monzonite stocks of the Crandall quadrangle; Iddings believes this radiation to indicate that the central mass represented the root of a great conical volcano now eroded away, which he reconstructed to a height of ten thousand feet above the plateau at its present level. Mr. Hague fails to find any evidence of the building up of great volcanic piles, but compares the region to Iceland, where there are many centers of eruption and fissures through which the lava breaks forth, old sources of eruption in time becoming obliterated by fresh flows from newer vents.

The geologic maps of the Absaroka Folio show in very striking fashion the horizontal character of the flows and breccias where the digitate drainage intersects adjacent formations. The most conspicuous features shown by the map are the regular trend of the main divide on the southwest, parallel to the Ishawooa intrusive bodies, and the wonderful abruptness of the eastern gorges in contrast with the gentle slope of the streams which flow down to the high basin of Yellowstone Lake on the west. A conspicuous feature of the physiography is the remarkable curve from west to east of the head of North Fork Stinkingwater River, its head-water trend conforming exactly to the trend of Sunlight Creek, across the high divide formed by intrusive bodies in the Sunlight mining region. The Absaroka folio is illustrated by reproductions from photographs showing the deep canyon of Clark Fork cut in archæan granite, Index Peak composed of breccias overlying palæozoic limestone above archæan rocks, other pictures of dikes and breccias, and a view of Sunlight Glacier, one of the small remnants of the great glaciers that formerly played an important part in the erosion of the plateau.

The geological history of the region is briefly as follows. Palæozoic and mesozoic sediments were deposited throughout a long period to a thickness of many thousand feet, and at the close of Laramie time, mountain-building took place, producing uplift and deformation that was contemporaneous in all the ranges of the northern Rocky Mountains. This post-Laramie movement produced

mountain ranges and plateaus which were considerably eroded before the first volcanic eruptions. These eruptions throughout Tertiary time are conceived to have had their manifestation by a variety of processes, in part building up volcanic cones, in part ejecting fluid lavas through fissures, and in part hurling out from vents which have left but few traces enormous masses of brecciated volcanic rock in a fashion that is without parallel in any region of active volcanoes. This great accumulation of surface lavas was later invaded by igneous magmas believed to be the elevated portions of a great complex of deep-seated crystalline rock; "where the underlying molten magma was subject to the severest pressure, the material was squeezed upward to higher levels following lines of least resistance, and consolidated at greater or less depths beneath the surface. . . . The line of Ishawooa intrusives marks the trend of one such upward movement of molten magma, which for the most part congealed without finding egress to the surface."

The two most remarkable features of Mr. Hague's observations in the Absaroka volcanic district are the enormous mass of breccias and the Tertiary granites and diorites. The explanation of the origin of the former as from divers vents along fissures and the demonstration of the coarsely crystalline character of the intrusive stocks add new evidence to dispel the time-honored but erroneous notion that great cones like Ætna or Vesuvius are essential features of great volcanic activity, and that granite is necessarily a very ancient rock. The Tarawera eruption of New Zealand and the fissure eruptions of Iceland show that the cone is an incidental product of eruption, not an essential. Geikie has brought forward, in his *Ancient Volcanoes of Great Britain*, much evidence to show that similar fissure eruptions were the prevailing type that produced the Tertiary basalt plateaus, and he too describes coarse granitic rocks of Tertiary age. The chief point of difference in the Absaroka Range is in the *brecciated* character of the horizontal lavas; the brecciated fragments are of all shapes and sizes and of great variation in kind, but nearly always volcanic. How did these breccias first crystallize as andesites or basalts in what were presumably continuous bodies of some sort, and later become broken up? This is a problem that has long puzzled the Yellowstone geologists, and for its complete solution an extended study and comparison of similar tuffs and breccias throughout the Cordilleran district will probably be required.

T. A. Jaggar, Jr.

PETROGRAPHY.

Experimental Petrography. — With the increasing number of experiments being made in the attempt to discover the laws governing the formation of crystalline rocks from their magmas some important truths should soon be disclosed. The latest contribution to the subject has recently been made by Bauer,[1] who worked along conventional lines. He fused powdered rocks, mixtures of powdered minerals, and mixtures of chemical compounds, with and without the addition of "mineralizers," held them at temperatures of 1000°–1400° for ten or more hours, and then allowed them to cool. Unfortunately he was unable to prolong the cooling stage to any great extent, and consequently the products obtained were largely glassy.

The wolframates, boric acid, and borax served well as "crystallizers." Under the influence of the first, quartz was produced, and with the aid of the other two, hornblende. The addition of the chlorides and fluorides to the mixture appeared to serve simply to lower the fusing point.

The quartz was obtained as irregular grains in a mass composed of a groundmass of glass, enclosing small laths of feldspar and larger crystals of orthoclase, albite, olivine, and nepheline. This was produced by fusing a mixture of orthoclase, albite, mica, hornblende, sodium chloride, potassium tungstate, boric acid, and sodium phosphate. The quartz is thought to have originated in the breaking up of the mica.

The hornblende was obtained in three experiments. The most interesting consisted in the fusion of a mixture of powdered phonolite and nepheline-basalt, neither of which contained any trace of the mineral. The hornblende was a bright-green variety. In one of the other two experiments powdered diorite was fused with boric acid, sodium phosphate, and calcium fluoride at a temperature of 1000°. The resulting hornblende was brown, while that in the original diorite was green.

The third experiment yielded also brown hornblende. In this powdered hornblende was fused with sodium and calcium fluorides and magnesium chloride.

Another interesting result reached was the discovery that the same mixture under different conditions of temperature and rates of cooling may yield entirely different products. For instance, the powder

[1] Bauer, K. *Neues Jahrb. f. Min.*, etc., Bd. xii, p. 535.

of a nepheline-basalt gave in one case a nepheline-basalt and in two other cases limburgites.

In order that the best results may be reached the author declares that specially prepared apparatus is necessary, but with a proper equipment he believes that much might be learned concerning the method of origin of the different types of igneous rocks by simple fusion experiments.

Notes. — The dikes cutting the mica-gneisses in the vicinity of Johns Bay, Maine, are similar in all essential respects to those near Portland in the same state. Miss Bascom[1] reports that two are olivine diabases, and a third is nonolivinitic.

Gratacap issues a plea[2] for a more interesting display of rocks in museums than that one usually sees. He also suggests along what lines such a display might be constructed to be at the same time of interest and of value.

Judd[3] describes under the name of rockallite the peculiar rock of Rockall Island in the Atlantic, 240 miles west of Ireland. The rock consists of ægirite, quartz, and albite in the proportions 39 : 38 : 23. The albite is sometimes porphyritic. An analysis gives :

SiO_2	Al_2O_3	Fe_2O_3	MnO	NiO	MgO	CaO	K_2O	P_2O_5	Total
73.60	4.70	13.10	93	.06	.11	.37	6.96	=	99.83

The structure is granitic. Its systematic place is in the granite group, although its feldspar is solely albite.

The rocks gathered by the International Boundary Commission along the newly surveyed boundary line between the United States and Mexico are granites, gabbro-diorites, diabases, diorite, porphyries, rhyolites, andesites, and basalts.[4] One of the rhyolites is spherulitic.

The collection of rocks made by Alexander Agassiz in the Fiji Islands contains specimens of granite, andesites, and basalts. Eakle[5] describes augite-andesite as the predominant rock of the islands. It varies from a very feldspathic type to a very basic type that appears to grade into basalt. In addition to this andesite there are also present hypersthenic and hornblendic varieties.

[1] *Amer. Geol.* (1899), vol. xxiii, p. 275.
[2] *Ibid.*, p. 281.
[3] *Trans. Roy. Irish Acad.*, vol. xxxi, Pt. iii, p. 39.
[4] Lord, E. C. E. *Proc. U. S. Nat. Mus.*, vol. xxi, 1899, p. 773.
[5] *Proc. Amer. Acad. Arts and Sci.*, vol. xxxiv (1899), p. 581.

Cole[1] suggests an approximately quantitative method for determining potassium in the constituents of igneous rocks. It is a blowpipe method differing from Szabo's in that the assay is fused in a bead of sodium carbonate. The advantages of fusing with sodium carbonate in place of the gypsum used in the Szabo method are: (1) The certainty of differentiating the potassium from the sodium flame; (2) complete decomposition of the assay; (3) security against loss of the assay; (4) convenience.

[1] *Geol. Mag.*, March, 1898, p. 103.

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CONTENTS

PAGE

I. On the Life History of Autolytus Cornutus and Alternate Generation in Annelids . . . . P. CALVIN MENSCH 165

II. Some Notes on Regeneration and Regulation in Planarians FRANK R. LILLIE 173

III. Remarks on the San Marcos Salamander, Typhlomolge rathbuni Stejneger . . . . W. W. NORMAN 179

IV. On the Frequency of Abnormalities in Connection with the Postcaval Vein and its Tributaries in the Domestic Cat (Felis domestica) C. F. W. McCLURE 185

V. The North-American Jumping Mice . . . . . . J. A. ALLEN 199

VI. Fresh-Water Aquaria . . . . L. MURBACH 203

VII. Synopses of North-American Invertebrates. VIII. The Isopoda, Part I . . . . HARRIET RICHARDSON 207

VIII. Reviews of Recent Literature: *Anthropology,* Payne's New World — 231
Zoölogy, Koelliker's Reminiscences, Degeneration of Duodenal Glands in the Cat, Greeley on Tide-Pool Fishes of California, Development of Brain Structures in Amia, Scapanorhynchus and Mitsukurina, The Lateral Line of the Toadfish, Greene on the Lateral Line of the California Toadfish, Absence of Retinal Pigment in the Dogfish, Pupa-Grafting in Moths, Amitotic Followed by Mitotic Cell Division, A New Unattached Hydroid, Hydra Grafts, Notes — 232
Botany, Minnesota Plant Life, The Local Floras of New England, Botanical Notes 238

IX. News 244

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ON THE LIFE HISTORY OF AUTOLYTUS CORNUTUS AND ALTERNATE GENERATION IN ANNELIDS.

P. CALVIN MENSCH.

The claim for the presence of an alternation of generation in annelids owes its origin chiefly to the results obtained in study of the family of syllidians by the earlier authors, Milne-Edwards, Savigny, De Quatrefages, Krohn, and more recently by A. Agassiz. What subsequent proofs of the presence of this condition in annelids have been presented still find their strongest support in the phenomena observed in a division of this family, that of Autolytus.

In forms of Autolytus, like *Autolytus cornutus*, described by Agassiz, after the young and so-called asexual animal has attained a certain length, a new head is developed on the fourteenth setigerous segment, and in this way the individual becomes divided into what is known as the parent stock, including the original head with its segments, and the bud or stolon, including the new head with the remaining segments. The stolon contains the maturing sexual products, and after these reach a certain stage of maturity it separates from the

parent stock and becomes free-swimming. The parent stock, as soon as the stolon is separated, regenerates the lost segments and in like manner develops a second and possibly a third or fourth bud. (In some forms of Autolytus (*A. varians*) the regeneration of new segments takes place before the shedding of the mature stolon, and thus a chain consisting of, at times, as many as eight stolons in different stages of development, becomes attached to the parent stock. In *Autolytus cornutus*, however, as in Proceræa, the stolon matures and becomes separated before an addition of new segments takes place, so that the parent stock of this form never bears more than a single stolon at a time.) During the process of separation the stolon undergoes such changes as are of service to it in the change of its life from among hydroids to that of surface swimming, the most conspicuous of which are the modification of the parapodia and the development of the swimming setæ. The sexual differences, as will be seen in comparing the free stolons, are also very conspicuous and appear quite early in the development of the stolon.

The free-swimming male stolon of an Autolytus was first described by Oersted, in 1843, as a new species of annelid to which he gave the name Polybostricus, while the free female stolon of another species (*Autolytus prolifera*) was similarly described by J. Müller, in 1853, under the name of Sacconereis. It was not until 1862, however, that Agassiz, in observing the separation of the stolon in *Autolytus cornutus*, demonstrated for certain the relation of the parent stock and stolons.

Alternate generation for annelids was first suggested by De Quatrefages in 1843, after observing a part of the budding process in a syllid (*Syllis monilaire*) previously described by Savigny ; later again by Krohn, in 1852, for *Syllis prolifera*, but the first complete description of the process was given by Agassiz, in 1862, in a paper entitled "On Alternate Generation of Annelids and the Embryology of Autolytus Cornutus." The development of the stolons of this syllid and their subsequent separation he followed stage by stage, and established the identity of the separately described Polybostricus and Sacconereis without a doubt. The stolons he described as sexual indi-

viduals which have been separated from the parent stock by a process similar to that of fission. The parent stock he regarded as distinctly asexual and as reproducing only by the separation and budding out of sexual stolons. A diagram of Agassiz's description of the cycle of generation would therefore be as follows :

Stolon = × < Eggs
Egg = Parent Stock
Stolon = × < Eggs

In this wise he attributed to *Autolytus cornutus* a distinct alternation of generation — in reality the only accurate alternate generation ever described for any annelid, and his original diagram of *Autolytus cornutus* still stands in some of our recent zoölogical text-books as a classical figure for the verification of alternation of generation in annelids.

The asexual condition of the parent stock is, however, not as constant as was supposed by Agassiz. In many of the specimens examined, particularly in individuals from which a first stolon has been separated, sexual products appear in the twelfth and thirteenth and even at times in the eleventh segment of the parent stock. At the time when the first stolon, *i.e.*, the stolon which originally formed a part of the body of the parent stock, becomes filled with sexual products none of the segments of the parent stock give any indication of the presence of reproductive products. In older individuals, however, in which apparently after a second or possibly a third stolon has been separated, I have found reproductive products in some stage of development in a large number of the specimens examined. Of such parent stocks found with reproductive products, by far the greater number were females, and of these I have been able to obtain individuals in which the ova had attained a size almost equal to that of mature ova. The different stages in the development of the sexual products I have been able to follow more successfully in a near relative of Autolytus, *Procerœa ornata*, the budding of which is in all respects similar to that of *Autolytus cornutus*. Of this species I have been able to find female specimens of parent stocks with ova in all stages of development up to the time when the ova are discharged from

the body. The egg-sac, which it may be assumed also appears in these specimens, I have not been able to observe.

The external appearances of a parent stock with reproductive products in the stages of development in which I have been able to observe them differ very little from a parent stock in which no such products are as yet present. Occasionally I have found that the anterior eyes appear somewhat larger, but no modifications of the parapodia, such as would indicate the epitokal condition so common in other syllidians, were observed. In all sexually mature parent stocks of Proceræa I have found a third pair of eyes near the inner insertion of the palps. These are present as mere pigment spots in very young individuals of both Proceræa and *Autolytus cornutus*, but as a rule disappear or remain very inconspicuous in the adult. In several of the specimens in which the ova were nearest mature, conspicuous ventrally directed lenses were present. A similar development of this third pair of eyes I have observed in the epitokal syllid Odontosyllis, taken at a time when the eggs have reached complete maturity; so that the appearance of this pair of eyes in the parent stock of Autolytus at this time might, I think, be looked upon as partaking of the epitokal condition in other syllidians.

The percentage of parent stocks found with sexual products is by all odds too great to be looked upon as merely accidental. In a number of individuals examined, from all of which the stolons had recently been separated, and in which regeneration of segments was taking place (in this way eliminating as far as possible such individuals as are developing a first stolon), reproductive products were found to be present in as many as five out of twenty specimens examined for *Autolytus cornutus*, and in as many as six and sometimes seven out of twenty specimens of Proceræa examined. The stages of development of the reproductive products varied from early stages in which the presence of sexual cells could only be determined by the examination of sections to the more mature ova already referred to. By eliminating the apparently less mature individuals and selecting only such as would indicate by their size and general appearance that at least a second stolon had been separated, as many as ten to twelve out of twenty specimens were found to contain sexual

products. Such conditions would strongly indicate that the presence of reproductive products toward the close of the phenomenon of budding is a constant stage in the life history of these syllids.

The life history of *Autolytus cornutus* would, therefore, consist in: (1) The development, from the egg, of the parent stock; (2) the development of sexual products in segments posterior to the thirteenth setigerous segment, the development of a head on the fourteenth, and the separation of these segments for the formation of the free-swimming stolons, Polybostricus (♂) and Sacconereis (♀); (3) regeneration of the lost segments and the formation in this way of a second and possibly a third or fourth stolon; (4) finally, the development in the parent stock of sexual products and the conversion of it into a sexual individual (Fig. 5). While the sexual products are forming, the regeneration of lost segments is still taking place, but in none of the specimens found had this new growth gone farther than the formation of a small bud, consisting of no more than eight or ten distinct segments.

As compared with a diagram of the cycle of generation as described by Agassiz, we would then have:

$$
\begin{array}{r}
\text{Stolon} = \times < \text{Eggs} \\
\text{Eggs} = \text{Parent Stock} = \times < \text{Eggs} \\
\text{Stolon} = \times < \text{Eggs}
\end{array}
$$

This would therefore be, not a sexual generation alternating with an asexual, but at most no more than a sexual dimorphism — a sexual individual budding off sexual stolons, and as its own sexual products mature, partaking more or less of the epitokal form of other syllids and itself becoming sexual.

Alternate generation has also been claimed for chain-forming syllidians, as Myrianide; but the presence of reproductive products in the posterior segments of the parent stock is of so common occurrence that the existence of such a generation has already prior to this been disputed by St. Joseph and Malaquin.

Korschelt and Heider in their text-book of *Comparative Embryology*, in accordance with the papers of Krohn and Agassiz, describe this process as a true alternation of generation, and hold it as distinctly different from the fission in Ctenodrillus,

Protula, and Nais, in which all divided individuals are sexual and alike in all respects, and which, they assert, cannot be regarded as a true alternation of generation. They summarize the budding of Autolytus as "a process that is to be placed alongside that of strobilization in the Scyphomedusæ." The presence of reproductive products in the parent stock of Autolytus throws doubt upon this comparison, and it appears to me more plausible to place these forms alongside the processes described by Brooks for the Hydromedusæ (*Mem. Bost. Soc. Nat. Hist.*, Vol. III, No. 12). Particularly striking in this respect is the similarity in the life history of *Autolytus cornutus* to the life history of *Cunina octonaria*, which he gives in a diagram as follows:

Hydra = Medusa × < Eggs
Egg = Planula = Actinula = Medusa × < Eggs
Hydra = Medusa × < Eggs

Here, according to Brooks, there is asexual multiplication without alternation of generation. Since in *Autolytus cornutus* and Proceræa the parent stock also becomes sexual, just as does the actinula, we would have, in the life history of these syllids, nothing more than the parent stock undergoing asexual multiplication, and forming stolons just as in the asexual multiplication of the actinula to form hydra. Taking the meaning of alternation of generation, as defined by Brooks in his work on the Hydromedusæ, as the commonly accepted one, — a definition which is also in accord with the descriptions given by Korschelt and Heider, — we would have in the syllids, for which a true alternation of generation has been claimed, no alternate generation at all, but simply a dimorphism resulting from an asexual multiplication of the parent stock.

Without taking into consideration the morphological value of the stolon it would appear more plausible, therefore, to regard stolonization in Autolytus as a process akin to that of fission in other annelids — unlike the fission in Dero, Ælosoma, and other forms where the divided individuals are identical in all respects, in that it has direct reference to the distribution of the sexual products, yet similar to these in that all the resulting divisions are in reality sexual individuals.

Another aspect of this question is, however, presented by the morphological characters of the stolon itself. In the process of its development the stolon has been provided with a head very similar in structure to that of the parent stock, and with eyes even larger and more advantageously placed than those of the parent stock. The alimentary canal, moreover, is in a state of degeneration; the crowding of the reproductive products, particularly in the female stolon, has greatly reduced its calibre, and to all appearances it has ceased to function. Organs for the prehension of food are absent, a mouth-opening being formed simply by a union of the broken intestinal wall with the hypodermis, and it is quite evident, by the changes that have taken place in the alimentary canal of the mature stolon, and also by the continuous absence of food particles within it, that the stolon in its free-swimming stages does not feed. The stolon would then in reality reduce itself to a series of segments, some of which, in the male, or a large number of which, in the female, are gorged with reproductive products and provided with organs fitted for the proper distribution of the reproductive products — a condition similar to, but, by virtue of a head formation, more advanced than that which has been described for the sexual fragmentation in the Palolo worm. While the stolon must, for want of a better expression, be regarded as a distinct individual, in connection with the problem of alternation of generation the morphological value of such a structure might well be questioned.

The existence of a true alternation of generation in annelids so long as it is supported alone by the phenomena presented by Autolytus seems to me far from being established, and it is doubtful if a more extended study of any of the syllidians would add more to this proof. The presence of reproductive products in even a smaller percentage of parent stocks than were found in *Autolytus cornutus* or Proceræa could still hardly be looked upon as of purely accidental occurrence. Instead of regarding the presence of such sexual products in the parent stock of Autolytus as accidental, it seems to me more plausible to regard it as the continuance of a more primitive condition in which the animal *in toto* assumed, at the ripening of the sexual

products, an epitokal form like that in Eusyllis, Odontosyllis, and Exogone, and stolonization as a secondary condition acquired for the purpose of a more perfect distribution of the sexual products. The complete epitokal changes in Autolytus have already been observed by Malaquin in *Autolytus lorgeferiens*, and described by him under the name of "epigamie," and it is very probable that a further study of the different species of Autolytus found along our coast would yield similar results. From our present knowledge it would appear that, as in *Autolytus cornutus*, the epitokal changes have been lost, or at least in greater or lesser part suppressed, in the parent stock of some syllids, and that in this way closely related forms of syllidians may exhibit sexual changes as various or more so than are shown in different species of Nereis; but it is very doubtful whether in any of our species the loss of sexual products has been so equally shared with these other changes as to leave a distinctly asexual parent stock.

The high development of the head of the stolon would form the strongest argument in favor of the distinct individuality of the stolon. Malaquin (*Recherches sur les Syllidiens*) has, however, already shown that the head of the stolon in different species of syllidians presents very different grades of development. In making this comparison he says: "L'individualisation du stolon diminue de plus en plus, au fur et à mesure qu'on suit la marche graduelle de ce phénomène. ——— autrement dit la tête qui marque pour ainsi dire le degré de perfectionnement de son individualité, se simplifie de plus en plus et arrive même à ne plus se former du tout." His figures, in which he compares the head of the stolon of *Haplosyllis hamata*, in the formation of which no development of a head takes place, with that of Trypanosyllis, in which a small head supplied with eyes is present, and, by different intermediate forms, with the complicated head structures of Autolytus, very clearly indicates, as had already been suggested by Huxley, that the stolon among syllids is not as distinctly individualized as would appear in observations on Autolytus by itself.

URSINUS COLLEGE, COLLEGEVILLE, PA.,
Jan. 13, 1900.

SOME NOTES ON REGENERATION AND REGULATION IN PLANARIANS.

FRANK R. LILLIE.

I. The Source of Material of New Parts and Limits of Size.

Many observers have noted the tendency of planarians kept without food to diminish in size. My attention was specially directed to this phenomenon by some experiments undertaken to test the effect of external conditions on the regeneration of *Planaria maculata*. I had already studied the effect of temperature on the regeneration of this form in conjunction with Mr. Knowlton.[1] I next undertook to test how far the chemical constitution of the medium affected the rate and form of regeneration. As an introduction to the systematic study of this subject, I made some experiments to determine whether any of the substances dissolved in the water of the habitat is necessary for regeneration. For this purpose I redistilled some of the ordinary distilled water of the laboratory, using flasks of Jena glass to get rid of the minute traces of copper found in water from copper stills. Permanganate of potash was dissolved in the water in the Jena flask to destroy traces of organic matter, and the distillate was again distilled in the same manner to insure the greatest possible degree of purity. The redistilled water thus obtained was carefully oxygenated by running a stream of air through it.

The pieces of planarians used for the experiments were washed in this water and then transferred to more of the same; the vessels (cleaned in strong acid) and water were changed frequently to get rid of any traces of bacterial growth. I soon found that under these circumstances regeneration went on as

[1] Lillie and Knowlton. The Effects of Temperature on the Development of Animals, *Zoöl. Bull.*, vol. i.

rapidly and as well as in tap water or the water of the habitat; thus demonstrating that the substances contained in these waters were not necessary for regeneration.

However, the decrease in size already mentioned was so rapid and marked as to appear to deserve special study. So I isolated a number of active planarians in the redistilled water, measured them, and kept them in a thermostat at temperatures that ranged from 20° to 27° C. The dishes and water were changed regularly and frequently, measurements of each individual being made at the same times. The table on the opposite page shows the history of these specimens; less than half of the actual measurements in this series are given.

It will be noted that the rate of decrease was not the same in all; in 2, for instance, it was much more rapid than in the others. This is probably due in part to greater activity of 2. Nor is the rate perfectly uniform in any given specimen, probably owing to variations in the temperature and in activity at different times.

The smallest specimen obtained (No. 5, after 43 days) was certainly less than one-hundredth the bulk of the original animal. Its length was one-fifteenth the original length, its width one-third the initial width, and if we suppose that its dorso-ventral diameter was reduced by only one-half, the bulk would be one-ninefieth of the original bulk. But there can be little doubt that its dorso-ventral diameter was reduced more than one-half.

Increase by fission was entirely stopped, but, on the other hand, the power of regeneration remained. Thus, when No. 5 had been reduced to less than one-half its original length, it was cut in two parts, and both regenerated completely, *although with constant diminution in bulk.* The same experiment succeeded in No. 3, after it had been starved to less than one-fourth its original length.

It is thus demonstrated that from a given individual one of less than one-hundredth the original bulk may be produced by appropriate means. This constitutes a criticism on those experiments that have been made to determine the limits of regeneration in planarians by direct operation. The possible

Days.	1.	2.	3.	4.	5.
1	7 × .7	7 × .5	10 × 1	6 × .5	9 × .75
5	7 × .7	5.5 × .5	7 × 1	6 × .5	8 × .75
12	6.5 × .5	4 × .33	6 × .66	Dead.	5 × .5
17	6 × .5	4 × .33	5 × .4		4 × .3
23	4 × .5	2.5 × .5	4.3 × .5		3.25 × .3 Cut in two.
25		Cut in two.			1.75 × .3 (head) 1.25 × .3 (tail)
27	3.7 × .4	1.25 × .3 (head) Partial regeneration. Died.	4 × .4		1.75 × .3 (head) 1.25 × .3 (tail) Partial regeneration.
33	3 × .4		3 × .4		1.4 × .3 (head) .9 × .3 (tail) Complete regeneration. Anterior piece died two days later.
40	2.3 × .4		2.7 × .4		.6 × .25
43	1.9 × .4 Cut in two. Parts died in two days.		2.25 × .4 Cut in two. Tail end, 1.1 × .4; regenerated in four days (partly). Head end, .9 × .4; regenerated very little new tissue.		.6 × .25 Lost by accident.

Table giving history of five planarians in distilled water. The vertical columns should be read separately. There is a slight discrepancy in the measurements of 2 and 3 for 17 and 23 days, no doubt due to an error in observation. The column to the left gives the number of days from the beginning of the experiment. The measurements, made after 17 days with the ocular micrometer, have all been reduced to millimeters.

limits of regeneration have been found by such experiments to be not much less than one-sixteenth of the bulk of the original animal. That a much lower limit has not been found is due partly to the extensive exposure of internal tissues along the cut surfaces, and partly (perhaps) to limitation of variety of tissue, but certainly not, it would appear, to deficient size.

Do all organs suffer equally in the reduction? It might be expected that the organs of reproduction would suffer first, as they do not contribute to the life of the individual; but the specimens used in the experiments were not sexually mature, so this point was not settled. The other systems of organs were reduced in apparently similar proportions. Thus the intestinal diverticula in 5 were reduced to five on each side, and the branches of the longitudinal nerves were apparently equally reduced.

Does the reduction affect chiefly the size or the number of the cells? A careful histological study would be necessary to answer this question in detail. Not having made this, all that I can say is that the branched pigment cells lying near the surface, that are readily visible under a low magnification, are reduced to very few, but their size is not noticeably affected.

Do the processes of reduction retrace the steps of normal growth and development? I think that this question must be answered in the affirmative. Certain it is that specimens reduced by starvation to a smaller size than just hatched specimens of the same species resemble these in their general proportions, the relatively greater breadth in proportion to length as compared with mature specimens, the smallness of the cephalic lobes, and in the small number of the intestinal diverticula and branches of the longitudinal nerves. It would be interesting to determine whether or not these artificial embryos, as they might be termed, could under favorable circumstances repeat the steps to the mature and fully grown condition from which they were reduced. I see no reason to doubt that this is possible.

In regeneration, under the circumstances of these experiments, two processes are taking place side by side; not only is new tissue being formed at the cut end, but the old tissues are

undergoing a translocation and partial redifferentiation to accommodate themselves to the new proportion that must be assumed. The new tissue at the cut end must be formed entirely from the old tissue, and the final result involves, therefore, an extensive working over of the old material. The original tissues, with constant losses, owing to destructive metabolism, are moulded into the form of a new individual. In trying to form a mental image of the forces at work in this complex rearrangement, one can think only of an "internal mould" (an expression of Buffon to which Professor Whitman has called my attention). No less remarkable is the maintenance of form in individuals that gradually waste away to one-hundredth part or less of their original bulk. Such individuals in all stages of reduction appear normal in all respects, physiologically as well as morphologically. They are active and exhibit perfectly normal reactions, showing no indications of sickness.

VASSAR COLLEGE, Jan. 4, 1900.

REMARKS ON THE SAN MARCOS SALAMANDER, TYPHLOMOLGE RATHBUNI STEJNEGER.

W. W. NORMAN.[1]

THROUGH the kindness of Mr. Leary, Superintendent of the U. S. Fish Hatchery at San Marcos, Texas, the Biological Laboratory of the University of Texas became the possessor of a small number of living salamanders that came up from subterranean waters 181 feet below the surface.

It has been the aim of the writer to study the habits of these strange animals, but through ill-luck only a single specimen is at the present writing alive, and the new arrivals at the well are becoming scarce.

For a systematic description of the animals the reader is referred to Stejneger's paper in the *Proc. of the U. S. Nat. Mus.*, Vol. XVIII, No. 1088.

A good idea of the animal may be had from the pictures accompanying this description.

The animals were kept in a large shallow basin of water containing water plants and some small organisms, such as water fleas.

Unless disturbed, the salamanders appear at all times either resting, or very slowly walking along. They move a few steps at a time, wait awhile, and go again. They have no particular pose when quiet except that they always rest on their four feet, holding themselves up from the bottom of the vessel, and frequently retain the position of the legs as if in the act of walking. Indeed, this position represents them as if suddenly

[1] A few years ago the late Professor Norman secured a number of specimens of the Texas cave salamander for me, to enable me to study the structure of their eyes. He himself intended to study the habits of the species. In September of 1899, Mrs. Norman placed his notes and photographs in my hands, and these are reproduced in this paper. The notes are just as he wrote them. I have added as foot notes a few observations on living specimens kindly furnished me by Superintendent J. L. Leary, of San Marcos. — C. H. EIGENMANN.

stopped. This is beautifully shown in the photograph (Fig. 1) where the large animal has the left legs near each other, and the right far apart. If the vessel contains, for example, water-cress, they crawl in among the branches, stop as when walking on firm bottom, with the legs in such a position as fits easiest for gliding in among the twigs.

They are never seen to move faster than a slow, easy walk, except when disturbed by external stimuli.[1] Then one of three methods of locomotion may follow.

1. The walking speed may pass into a grotesque run by long strides and corresponding winds of the body; or, 2. This passes into a combined movement of legs and tail, the last act-

FIG. 1. — Photograph of a living salamander from the side.

ing as fin. 3. At its greatest speed the legs are laid lengthwise against the body, and the tail only used for locomotion.

The legs are exceedingly slender and weak. If the animal is placed on a table out of water, the body falls to the floor, and at best the animal may wriggle a few inches.

[1] The motion in water is, for the most part, slow and cautious, the movement of the long legs being apparently calculated to produce the least commotion in the water. The motion suggests that of a cat creeping upon its prey, or the elephantine progression of the snapping turtle. The feet are lifted high in walking, and the body is kept from the bottom by the full length of the fore arm and leg. In ordinary progression the body slopes from the nose to the tail, which drags (Fig. 1). The method of moving the limbs is as follows: Left hand and, when this is nearly ready to place, or usually when placed, the right foot. When the right foot is placed, then the right hand and then the left foot. As the hand of one side is not raised till the foot of the same side is placed, the enormous strides of the long-legged creature causes it to step on its hand or even beyond. Its natural gait is a deliberate progression by means of its feet with three feet usually on the ground. Any attempt at great rapidity by this means of locomotion results in a most undignified and futile wriggle. When going slowly the head is held sloping upward. When walking rapidly it is held sloping down, so that the snout is near the ground.

In water, however, the weight of the salamander is so little that the legs are amply strong for its locomotion. Professor Stejneger lost sight of this point when he guessed that the animal used its tail for locomotion and its legs as feelers, for he says: "Viewed in connection with the well-developed, finned swimming-tail, it can be safely assumed that these extraordinarily slender and elongated legs are not used for locomotion, and the conviction is irresistible that in the inky darkness of the subterranean waters they serve the animal as feelers."

No definite information has been obtained as to their habits in nature.

They show no reaction against light, either as a response by motion to the direction of the rays or to the quantity of light.

FIG. 2.—The same as Fig. 1, but from above.

If kept in a vessel, one-half of which is dark and the other half light, the animal is found about as much in one as the other, and on emerging into light from the dark half indicates in no way an awareness of the difference.

If in a tangle of plants, as watercress, they are found there about the same as in any other part of the vessel.

If they are headed against a current, the flowing water acts as stimulus urging them on. If the current strikes them from behind, they move more rapidly in the direction of flow.

The sense of touch is highly developed. There is, however, no experimental evidence that this is confined to any particular region. If the surface of the body is touched anywhere except at the blunt truncated snout, the animal responds at once by moving away. If the stimulus causes it to swim away, it may

go (say 12 or 16 inches) till it strikes the side of the vessel, after which it soon comes to a standstill.

If, however, it is struck say with the flat side of a scalpel handle sufficiently hard to move the entire animal even an inch backwards, it may not react, and this may often be repeated

FIGS. 3 and 4.

FIG. 3. — Dorsal surface of a salamander preserved in formalin.
FIG. 4. — Ventral surface of the same specimen.

before it reacts by moving away. A possible explanation of this is that in normal life it is every day striking itself against obstacles, especially the sides of the vessel (when in confinement).

The animal was kept in water about an inch deep, so that its head was near the surface. The waves of the water set going by a gentle puff of the breath act as a sure stimulus. It is exceedingly sensitive to any motion of the water.

But little evidence thus far shows in favor of a sense of smell. All attempts at feeding (except one) have been in vain. No attention was given to meat or other articles placed near it. Examination of a dead specimen showed chitinous remains of such Crustacea as Cyclops. To-day (April 18) I offered a salamander a small piece of the abdominal muscle of a crayfish. The bait was held by means of forceps about 5 mm. in front of the snout. The animal moved slightly forward, and the bait was kept at about the same distance. Suddenly it was snapped off and swallowed. The animal snapped off a second piece, but a third was refused.[1]

[1] If a glass rod or other object is held a little to one side and in front of the animal, it will cautiously turn its head in the direction of the rod. If the latter is then made to describe an arc about the side of the salamander, the head will follow it with a continuous motion, expressive of the greatest caution, as far as it can be followed without moving any of the limbs. A sudden jar, produced by tapping the rod on the bottom of the aquarium at such a time, causes the salamander to jerk its head back and rear back on its limbs as far as it can. The same effect is produced if the rod is introduced too rapidly.

If a piece of crayfish tail is held by pincers in the fingers a short distance in front or to the side of the head of the salamander, there is the same cautious motion forward till the snout comes in contact with it. There is then a momentary hesitation, followed by a sudden snap and seizure.

The salamander may be pulled from side to side by the meat, after it has once secured a hold, without causing it to let go. All of its caution is apparently directed in approaching the food without disturbance. After it has secured a hold it will struggle to maintain it.

ON THE FREQUENCY OF ABNORMALITIES IN CONNECTION WITH THE POSTCAVAL VEIN AND ITS TRIBUTARIES IN THE DOMESTIC CAT (*FELIS DOMESTICA*).

C. F. W. McCLURE.

VARIATIONS of the postcaval vein and its tributaries are not of unusual occurrence, as is attested by the considerable literature on this subject. It is also generally conceded that these variations from the normal condition, to whatever cause they may be due, occur with greater frequency among domesticated animals than among those living in the wild state.

The object of the present paper is to emphasize especially the frequency with which such venous abnormalities may occur in a given number of individuals of the domestic cat (*Felis domestica*).

During the last five years the writer has observed that variations of the venous system, of some sort or another, occur with great frequency in the domestic cat; and in 1898–99 twenty-five cats dissected by students in the Princeton Laboratory were more carefully examined for such variations, with the following results:

In only ten of the twenty-five examined was the venous system apparently normal, while in 60 per cent, or in fifteen of the cats, thirty-three distinct abnormalities were met with in connection with the postcava and its tributaries. These, for descriptive purposes, have been grouped in the following table under five types.[1]

The cats in which these abnormalities were found were chosen at random from those brought into the Laboratory and

[1] The figures represent the actual size of the preparations. The veins are in black and the arteries shaded. The numbering is the same for all of the figures. Many of the smaller arteries and veins have been omitted from the drawings.

were not, after dissection, selected on account of the abnormalities which they presented.

TYPES.	Number of Cases Observed
1. Persistent Posterior Cardinal Veins (*Vv. Cardinales post.*).	
(*a*) Left common iliac vein (*V. iliaca communis sinistra*) absent.	3
(*b*) Left common iliac vein (*V. iliaca communis sinistra*) present.	2
2. The Common Iliac Veins (*V. iliaca communis sinistra* and *dextra*) Unite to Form the Postcaval Vein Opposite the Middle of the Sixth Lumbar Vertebra, which is Considerably Cephalad of the Normal Point of Junction (opposite the posterior half of the seventh). The ilio-lumbar veins also, in each case, open into the right and left common iliacs and not into the common postcava, as is usually the case in the cat.	3
3. The Middle Sacral Vein (*V. sacralis media*) and its Relation to the Veins of the Pelvic Region.	
(*a*) Opens into the right common iliac vein (*V. iliaca communis dextra*)	4
(*b*) Opens into angle of union of two veins which join veins of right and left side, respectively	5
4. Perforation of a Vein by:	
(*a*) An artery	6
(*b*) A nerve	3
5. Double Veins where One is Normally Present . .	7
	33

Description of the Venous Abnormalities.

1. Persistent Posterior Cardinal Veins (*Vv. Cardinales post.*). — Our knowledge of the development of the postcaval vein and our interpretation of the significance of the persistent double postcaval veins are largely due to Hochstetter,[1] who has shown that these veins are the homologues of the posterior cardinal veins of the embryo and of lower vertebrates.

Wilder and Gage[2] state that double postcaval veins occur in the domestic cat once in about ten cases. This percentage is somewhat less than that found by the writer (20 per cent), but perhaps represents more accurately the conditions commonly met with. In either case the percentage is extremely large when we consider how rarely this abnormality is met with in man.

[1] Hochstetter. *Anat. Anz.*, Bd. ii, *Morph. Jahrb.*, Bd. xiii, and *Anat. Anz.*, Bd. iii.

[2] *Anatomical Technology*, § 962.

Five cases of persistent posterior cardinal veins were met with by the writer in twenty-five cats examined. In three of these cases the left common iliac vein (*V. iliaca communis sinistra*) was absent, and in two it was present.

(*a*) Persistent Posterior Cardinal Veins. Left Common Iliac Vein (*V. iliaca communis sinistra*) Absent.

The three examples of this type were essentially the same in character and are well represented by Fig. 1.

In each instance the union of the two posterior cardinals (17) with the common postcaval vein (1) took place in the neighborhood of the kidneys. In two instances this union was opposite the third lumbar vertebra, and in one, opposite the fourth. In the former the right renal veins, single in one case and double in the other, opened into the right posterior cardinal; in the latter (Fig. 1) the right renal vein (7) opened into the common postcava (1).

In each instance, as in Fig. 1, the single left renal vein (7) opened into the left posterior cardinal (17).

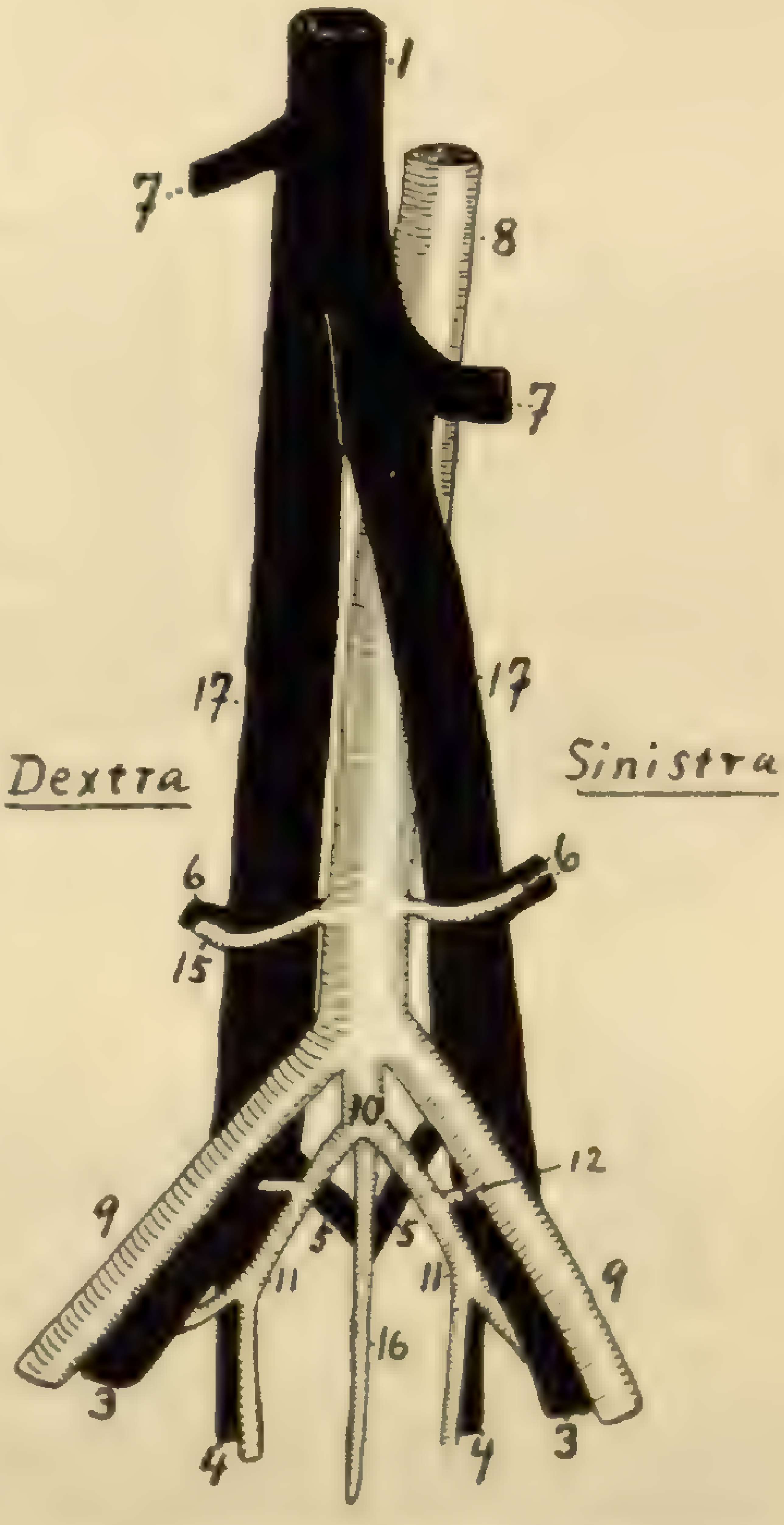

Fig. 1. — Princeton Morphological Museum, No. 601. Ventral aspect. *V. cardinalis dextra* and *sinistra* persistent. *V. iliaca communis sinistra* absent. 1. *Postcava communis.* 3. *V. iliaca externa.* 4. *V. iliaca interna.* 5. *V. sacralis media.* 6. *V. ilio-lumbalis.* 7. *V. renalis.* 8. Aorta. 9. *A. iliaca externa.* 10. *A. iliaca interna communis.* 11. *A. iliaca interna.* 12. *A. hypogastrica.* 15. *A. ilio-lumbalis.* 16. *A. sacralis media.* 17. *V. cardinalis post.*

The middle sacral vein (*V. sacralis media*), Fig. 2 (5), in each of these three cases, was connected with the posterior cardinal veins (17) in a characteristic manner. It opened into the angle of union of two veins which joined, respectively, the right and left posterior cardinal veins (17) at varying distances from the point of union of the external and internal iliac veins.

(*b*) PERSISTENT POSTERIOR CARDINAL VEINS. LEFT COMMON ILIAC VEIN (*V. iliaca communis sinistra*) PRESENT.

Abnormalities of this type have been described as occurring in man, by Cruveilhier, von Gruber, Kollmann,[1] Lobstein, Nicolai, Quain, Wilde, and others.

Kollmann, with whom the writer is fully in accord, states as follows regarding the significance of this type of abnormality: "The significance of this condition can, according to my interpretation, only be as follows: Persistence of both cardinal veins, together with the connecting branch (Verbindungsast)."

By the "Connecting branch" is meant the vessel which is subsequently developed between the veins of the left hind extremity and the right posterior cardinal vein, in correlation with the appearance of the functional kidneys and the atrophy of the distal portion of the left posterior cardinal vein. This vessel becomes the left common iliac vein (*V. iliaca communis sinistra*).

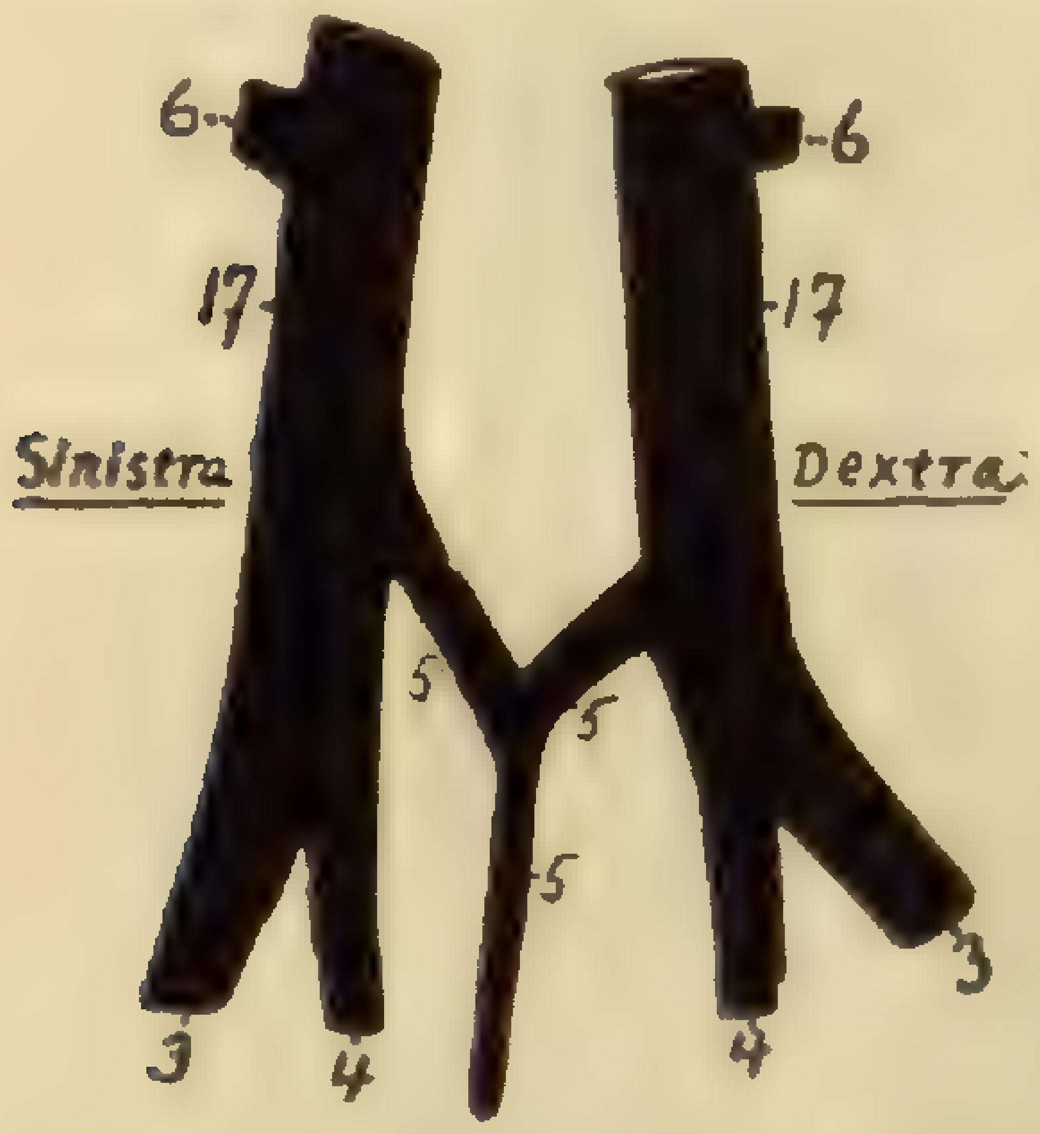

FIG. 2. — Dorsal aspect of Fig. 1. Arteries not indicated. *V. sacralis media* and its connection with *V. cardinalis dextra* and *sinistra*. For reference to numbers, see Fig. 1.

No instance was met with by the writer in which the "Connecting branch" ran in the reverse direction, that is, between the veins of the right hind extremity and the left posterior cardinal vein. Abnormalities of this type, however, have been described by Timmermann, Walter,[2] Walsham, and others, as occurring in man.

Two cases were met with by the writer in which the posterior cardinal veins were persistent, together with the "Connecting branch."

In one (Fig. 3) the union of the two posterior cardinals (17) with the common postcava (1) was opposite the third lumbar vertebra; in the other (Fig. 4) this union was opposite the middle of the sixth lumbar vertebra.

In the first-mentioned case, represented by Fig. 3, where the

[1] Kollmann gives a very complete bibliography relating to this type of abnormality in Bd. viii of the *Anat. Anz.*, p. 113.

[2] See Kollmann's *Bibliography*.

two posterior cardinals unite with the common postcava opposite the third lumbar vertebra, the middle sacral vein (*V. sacralis media*) opens into the angle of union of two veins which, as in that case previously mentioned (Fig. 2), join, respectively, veins of the right and left side.

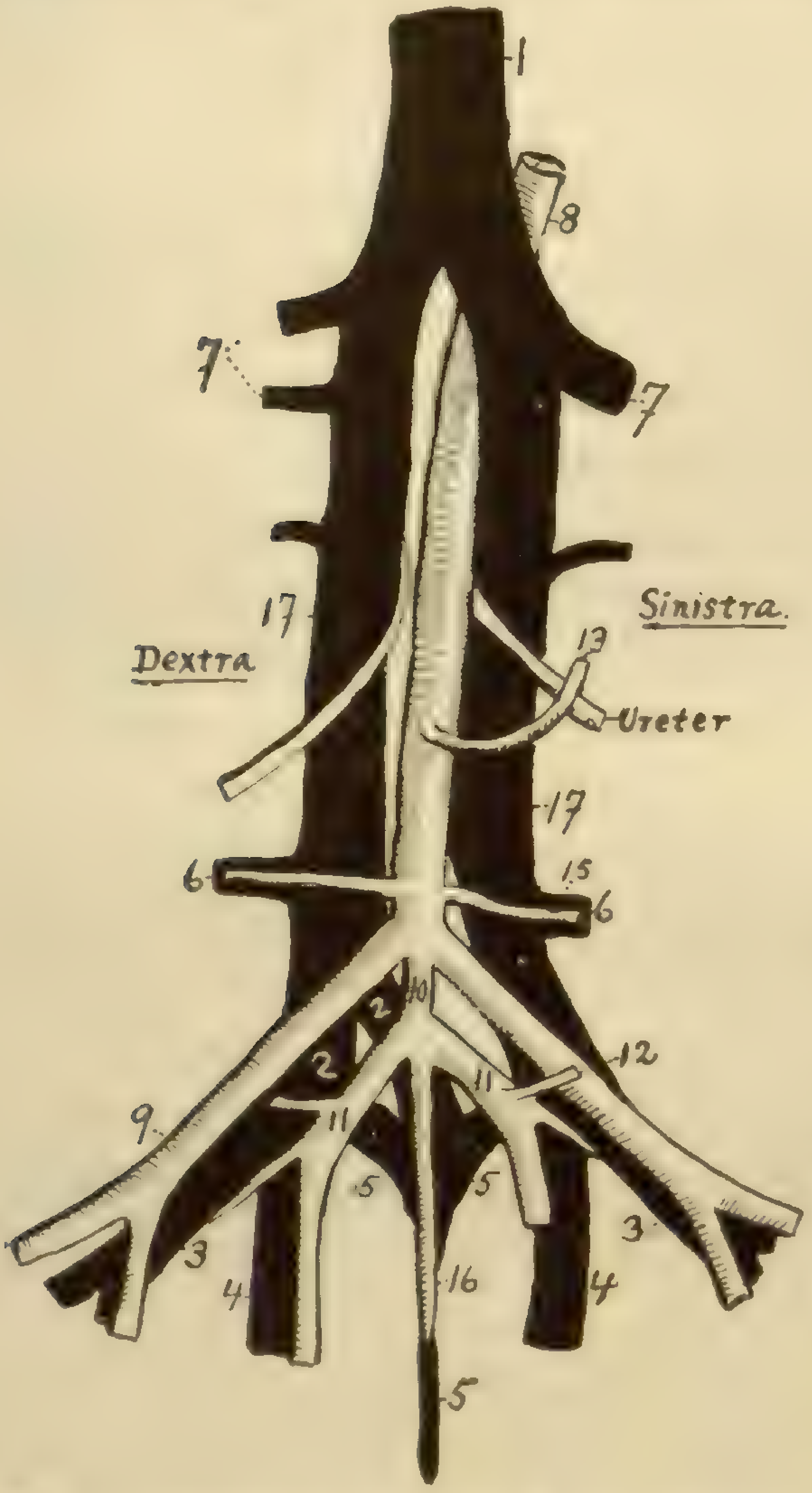

Fig. 3. — Princeton Morphological Museum, No. 602. Ventral aspect. *V. cardinalis dextra* and *sinistra* persistent. *V. iliaca communis sinistra* present. 2. *V. iliaca communis.* 13. *A. mesenterica post.* For remaining numbers, see Fig. 1.

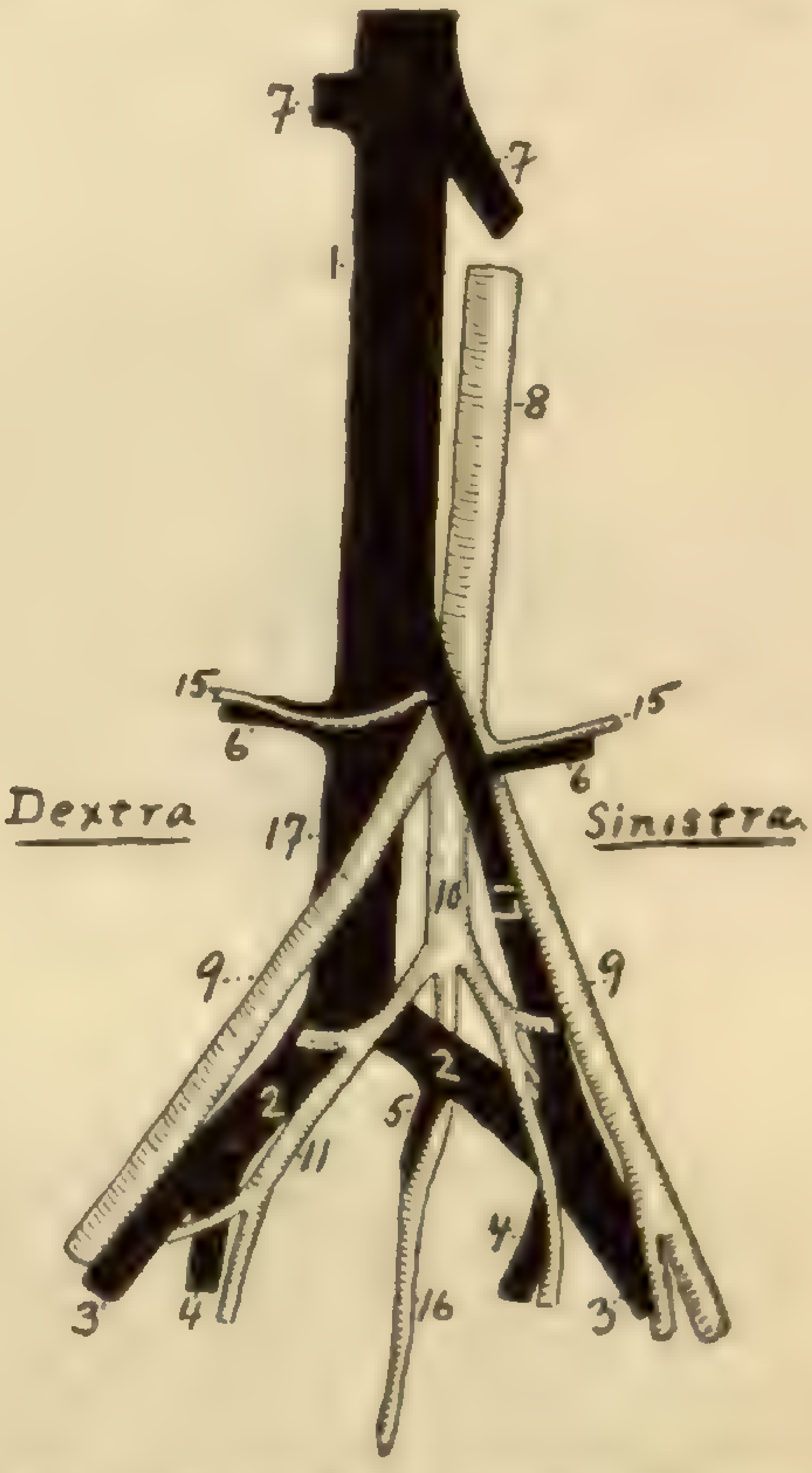

Fig. 4. — Princeton Morphological Museum, No. 603. Ventral aspect. *V. cardinalis sinistra* persistent, *ex parte*. *V. iliaca communis sinistra* present. 2. *V. iliaca communis.* For remaining numbers, see Fig. 1.

In addition to the above mode of union, which seems to be characteristic for the middle sacral vein, whenever both posterior cardinals unite in the neighborhood of the kidneys, the middle sacral vein again opens into the right post-cardinal by an additional vessel. This third vessel, Figs. 3, 5 (2, sinistra), extends between that portion of the middle sacral vein which opens into the left posterior cardinal and the right posterior cardinal vein. It opens into the latter, opposite the point where

the right external iliac artery (9), Fig. 3, arises from the aorta. Although the connection of this third vessel with the middle sacral vein is abnormal, its relative position, and especially its connection with the right posterior cardinal at the above-mentioned point, lead the writer to the conclusion that it is the "Connecting branch" (Verbindungsast) which normally grows between the veins of the left hind extremity and the right posterior cardinal vein, in correlation with the appearance of the permanent kidneys and the atrophy of the distal portion of the left posterior cardinal vein. This so-called "Connecting branch," under normal conditions, becomes the left common iliac vein (*V. iliaca communis sinistra*) and returns the blood from the left hind extremity to the postcaval vein. In this particular instance, however, the vein does not connect with the veins of the left hind extremity, but arises from the middle sacral vein by means of two radicles that soon become confluent, Fig. 5 (2, sinistra). The significance of this unusual connection will be spoken of in connection with the following topic.

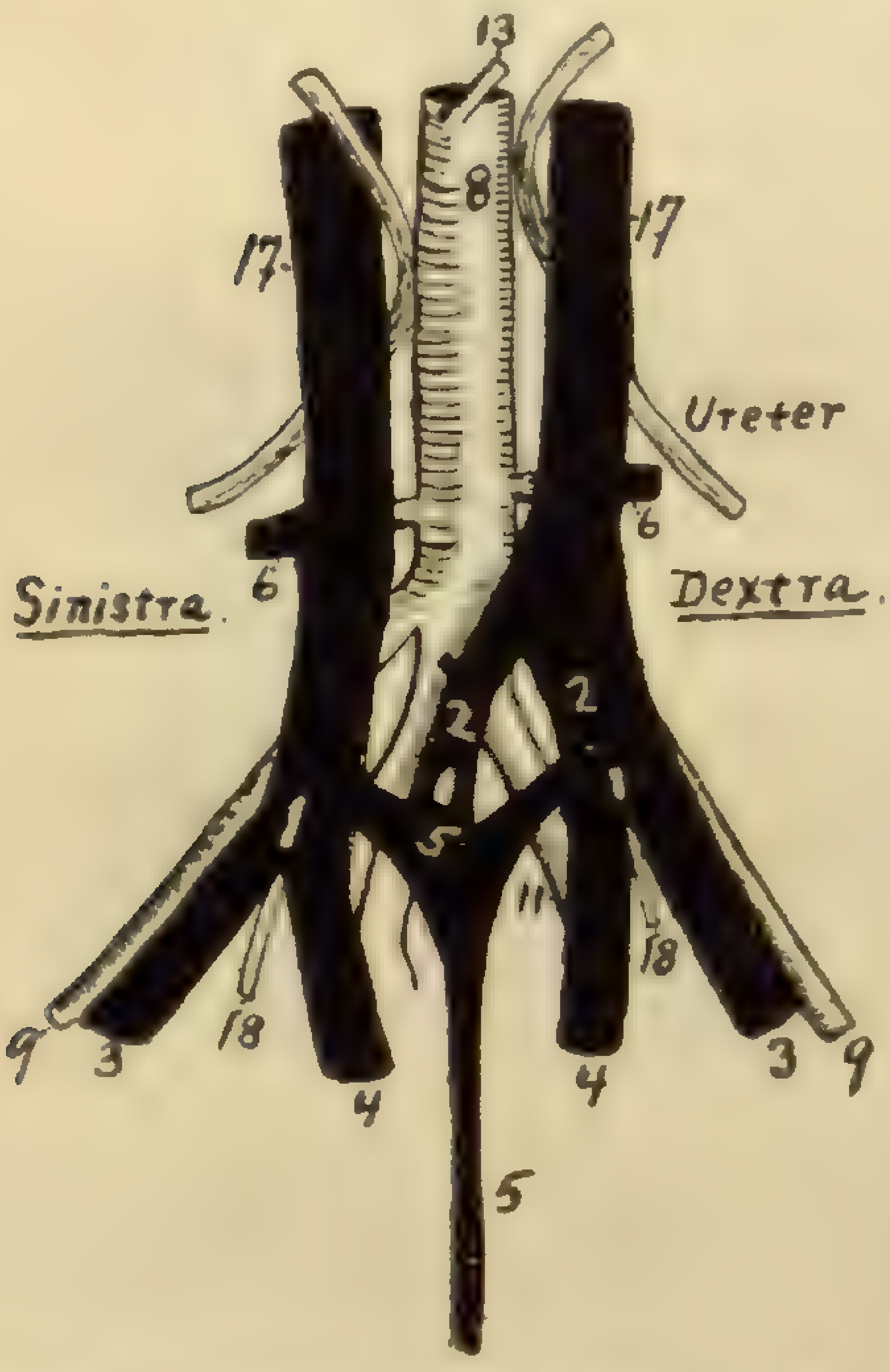

FIG. 5. — Dorsal aspect of Fig. 3. 2. *V. iliaca communis.* 13. *A. mesenterica post.* 18. *N. obturatorius.* For remaining numbers, see Fig. 1.

The second case met with by the writer, in which the posterior cardinal veins persist, together with the "Connecting branch" (*V. iliaca communis sinistra*), is represented by Fig. 4.

In this instance the persistent left posterior cardinal vein (17) unites with the corresponding vein of the right side, opposite the middle of the sixth lumbar vertebra, and not, as in the preceding case, in the region of the kidneys. The left posterior cardinal is also here of less importance physiologically, as is indicated by its relative size, than either the right posterior cardinal or the left common iliac vein (2). It is evident, therefore, that the bulk of the blood from the left hind extremity was carried to the common postcava, chiefly by the left common

iliac vein ("Connecting branch"), which is normal in every respect and has, as is usually the case in the cat, the middle sacral vein (5) opening into it. The ilio-lumbar veins (6), which, usually in the cat, open into the common postcava (1), in this instance (Fig. 4), open into separate vessels on the right and left side, respectively. That the vessel (17) on the left side, into which the ilio-lumbar vein (6) opens, is the left posterior cardinal vein and not the so-called "Connecting branch" is evidenced by the fact that the vein in question persists in common with the left common iliac ("Connecting branch"). In addition to this, the left posterior cardinal (17), in Fig. 4, lies ventrad of the aorta at the point where it unites with the corresponding vein of the opposite side, a circumstance characteristic of the left posterior cardinal vein.[1]

The "Connecting branch" is not usually present when the left posterior cardinal persists. Its absence, under these conditions, is undoubtedly due to the circumstance that the left posterior cardinal vein, during all stages of development, continues to collect the blood from the left hind extremity, which makes uncalled for the development of a vessel to share in its function. When for some reason the "Connecting branch" does persist, together with the left posterior cardinal, so far as the writer's experience extends, one vessel is usually developed at the expense of the other. This idea is well borne out by a comparison of Figs. 1, 3, and 4.

In the type of abnormality represented by Fig. 1, the "Connecting branch" is absent, and the left posterior cardinal persists as far forward as the kidneys.

In Fig. 3 the left posterior cardinal is likewise persistent as far forward as the kidneys, but the "Connecting branch," though present, collects little, if any, of the blood from the left hind extremity.

In Fig. 4 both vessels persist, but the left posterior cardinal is insignificant, while the "Connecting branch" is normal in every respect, and undoubtedly, on account of its large relative size, is the chief collector of the blood from the left hind extremity.

[1] In the preparation represented by Fig. 4 the common internal iliac artery (10) is unusually long. Compare with corresponding arteries in Figs. 1, 3, 6.

The middle sacral vein and the "Connecting branch" (*V. iliaca communis sinistra*) must be developed in close relation with each other, since the former normally opens into the latter. It is not strange, therefore, in one instance (Fig. 3) where the "Connecting branch" is abnormal, that it should arise from the middle sacral vein.

2. ON THE PRESENCE OF UNUSUALLY LONG COMMON ILIAC

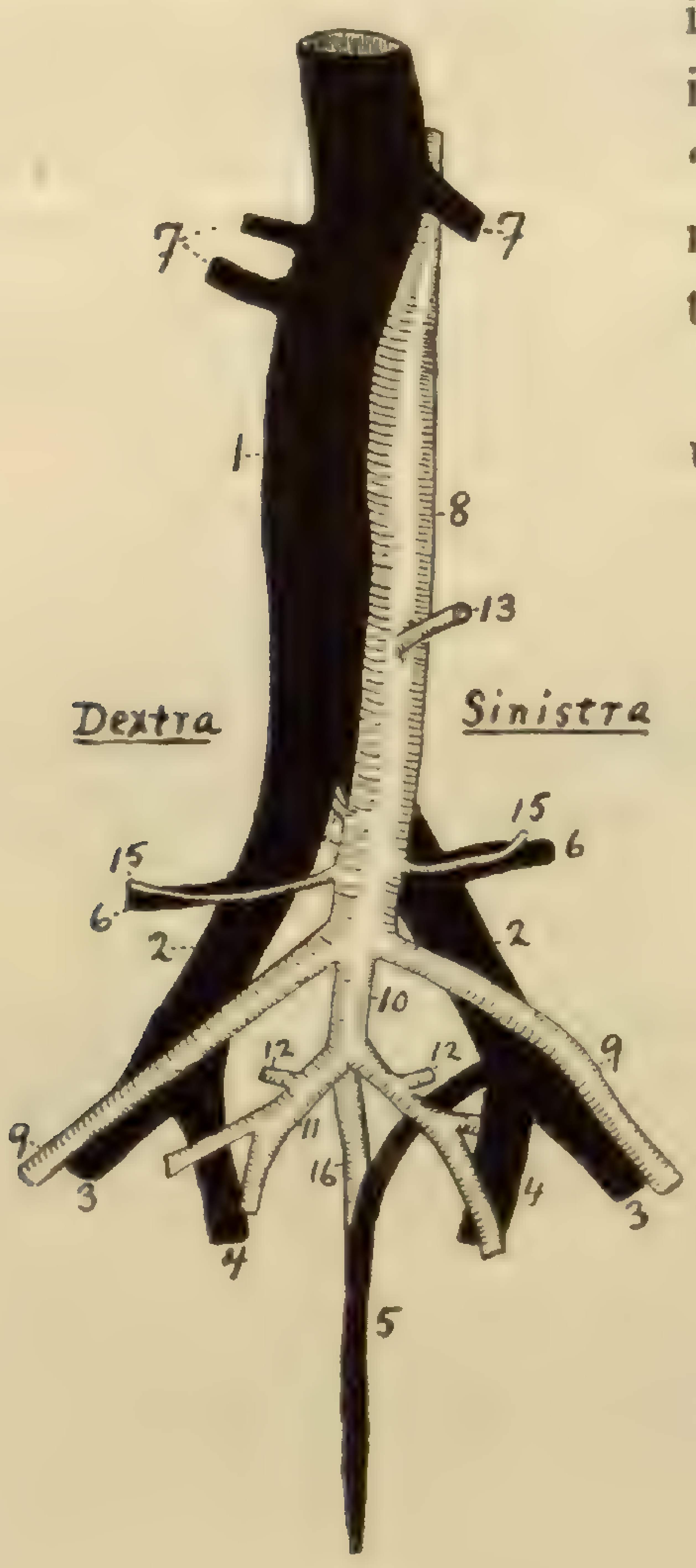

FIG. 6.

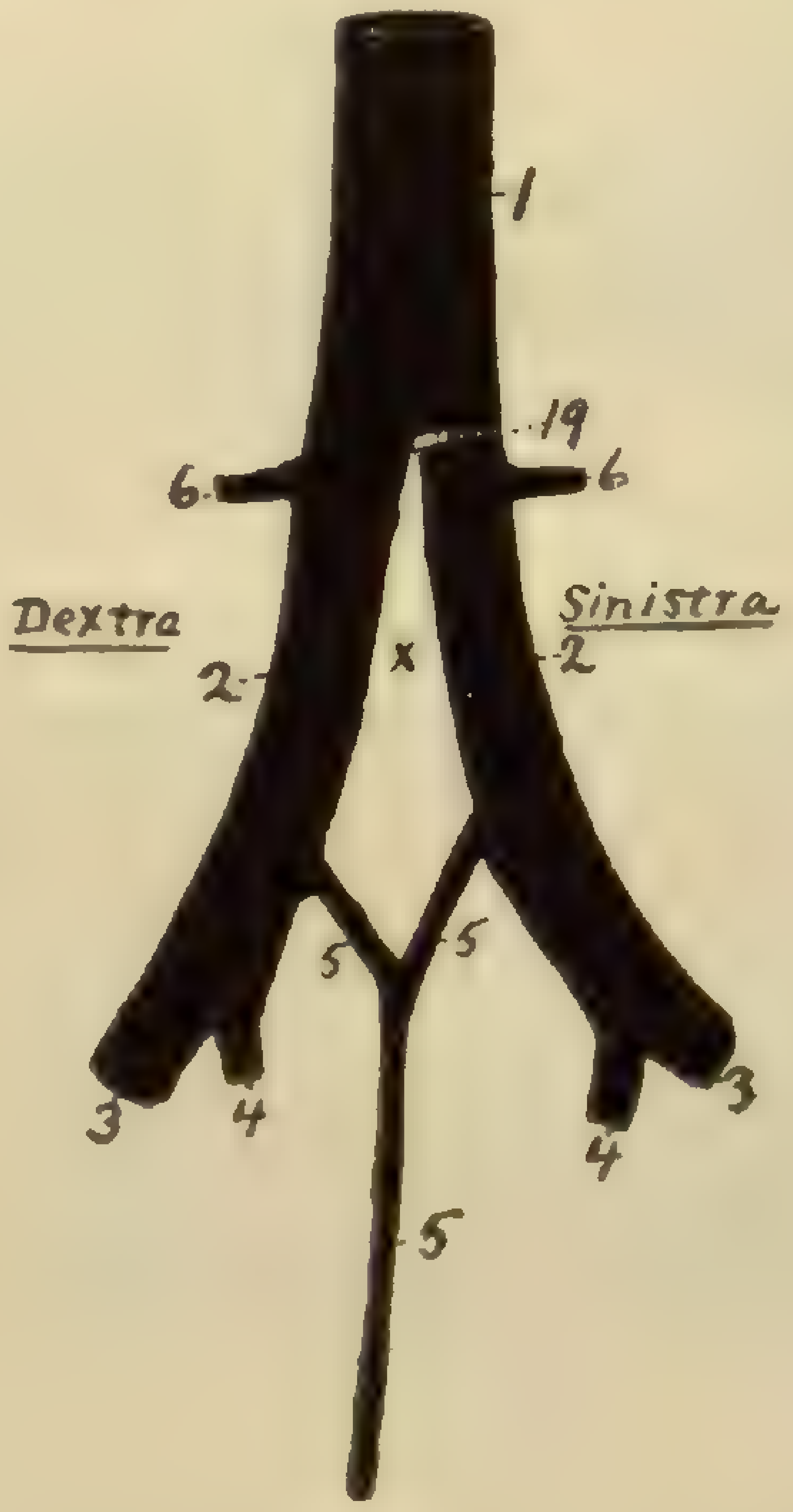

FIG. 7.

FIG. 6. — Princeton Morphological Museum, No. 604. Unusually long *Vv. iliacæ communes* which unite with postcava opposite the middle of the sixth lumbar vertebra. Ventral aspect. 2. *V. iliaca communis*. 13. *A. mesenterica post.* For remaining numbers, see Fig. 1.

FIG. 7. — Princeton Morphological Museum, No. 605. Same as Fig. 6. Ventral aspect. Arteries omitted in the drawing. 19. *A. lumbalis*. X. Opposite origin of *Aa. iliacæ externæ* from aorta. For remaining numbers, see Fig. 1.

VEINS (*Vv. iliacæ communes*). — The point at which the single postcava joins the right and left common iliac veins is normally, with slight variations, opposite the middle of the seventh lumbar vertebra. In three cats, not including those which possessed well-defined double postcaval veins, the point of union of the two common iliacs with the common postcava was found to be opposite the middle of the sixth lumbar vertebra,

which is considerably cephalad of the normal point, and to result in relatively long common iliac veins (2), Figs. 6, 7.

The writer was at first inclined to regard these three cases as instances in which the posterior division of the left posterior cardinal vein, instead of the "Connecting branch," persists as the functional left common iliac vein, and for the following reasons:

1. Because in one instance (Fig. 7) the middle sacral vein (5) opens into the angle of union of two veins, as in those cases in which both posterior cardinal veins persist (Fig. 1).

2. Because the left ilio-lumbar vein (6), in all three cases, opens into the left common iliac (2) and not into the common postcava (1), as is normally the case in the cat. (See Figs. 6, 7.)

3. Because the functional left common iliac vein (2), in all three cases, unites with the corresponding vein of the opposite side in front of the middle of the sixth lumbar vertebra and, in this respect, resembles the left posterior cardinal vein (17) in Fig. 4, which persists there, in addition to a left common iliac vein ("Connecting branch"). In other words, if the left common iliac vein (2) were absent in Fig. 4, the latter would resemble, so far as the veins are concerned, the conditions met with in Fig. 6.

One marked difference exists, however, between the relative position of the left common iliac (2) in the three cases cited above and that of the left posterior cardinal vein (17) in Fig. 4. In the latter the vein lies ventrad of the aorta, the position it should normally assume were the vessel a persistent cardinal vein. In the three other cases, of which Fig. 6 is an example, the aorta (8) lies ventrad of the vein, which should not be its position unless a transposition of the vessel has taken place, a circumstance incapable of proof. Whatever the significance of this abnormality may be, it is certainly worthy of mention, for it further emphasizes the fact that variations of the postcaval vein and its tributaries are of unusual frequency in the cat.

3. The Middle Sacral Vein (*V. sacralis media*) and its Relations to the Veins of the Pelvic Region. — Much has already been said concerning this vein, but its variations are so pronounced, that it seems best to specify them more in detail.

The middle sacral vein usually opens into the left common iliac, and this was found to be the case by the writer in 60 per cent of the cats examined. In some instances this vein (5) was found to open into the left common iliac (2), near the point of union of the external and internal iliac veins (3 and 4), Fig. 6. In other instances its connection with the left common iliac was somewhat cephalad of this point.

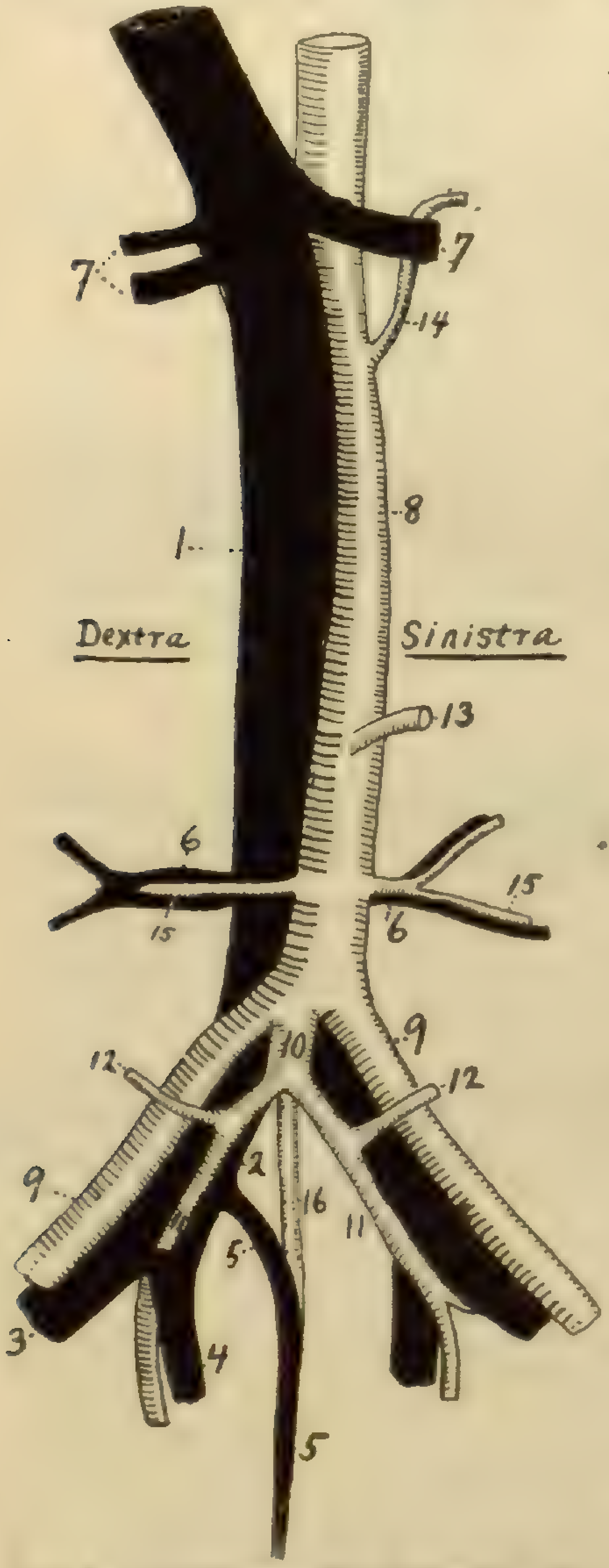

FIG. 8. — Princeton Morphological Museum, No. 606. Perforation of *V. iliaca communis dextra* by *A. iliaca interna dextra*. Ventral aspect. 2. *V. iliaca communis*. 13. *A. mesenterica post.* 14. *A. renalis*. For remaining numbers, see Fig. 1.

In four cats, or 16 per cent of those examined, the middle sacral vein (5) opened into the right common iliac (2), Fig. 8. This was the case with one of those preparations in which the common iliac veins were unusually long and joined the single postcava opposite the sixth lumbar vertebra.

In five cats, or 20 per cent of those examined, the middle sacral vein (5) opened into the angle of union of two veins which joined a vein of the right and left side, respectively (Figs. 1, 3, 7).

4. ON THE PRESENCE OF FORAMINA IN VEINS THROUGH WHICH ARTERIES AND NERVES PASS. — (*a*) Six cases were met by the writer in which a vein presented a completely formed foramen through which an artery passed. In four of these cases the internal iliac artery passed through a foramen in the common iliac vein. In the two remaining instances a lumbar artery passed dorsad through a foramen in the postcaval vein.

Two cases were met with in which the right internal iliac artery (11) passed through a foramen in the right common iliac vein (2), as represented by Fig. 8.

The foramen, which, in both cases, was situated near the juncture of the external and internal iliac veins, was complete, so that the artery could be dissected away from the vein without injuring the latter. After passing through the foramen the artery naturally lies dorsad of the vein, but in its subsequent course assumes its usual position at the side of the vein.

Two cases were met with, in which the left internal iliac artery passed through a foramen in the left common iliac vein. Since there is no essential difference between any of these four cases, so far as the character and relative position of the foramina are concerned, Fig. 8 will serve as a description for all.

Treadwell[1] has described an abnormality as occurring in the cat somewhat similar to these four cases described above, but on account of the poor condition of his preparation, he was unable to locate accurately the exact position of the foramen.

An examination of his figure leads the writer to the conclusion that his preparation is similar, in every respect, to that represented above by my Fig. 8.

The two cases in which a lumbar artery passed through a foramen in the postcaval vein resemble those mentioned above, so far as the completeness of the foramina is concerned, and, therefore, need no further mention. It is interesting to note, however, that in each instance the vein was penetrated by the same lumbar artery, the artery situated just cephalad of the ilio-lumbar artery.

(*b*) Foramina, when present, were not exclusively connected with the transference of arteries. In three cats both obturator nerves (18), Fig. 5, were found to pass through foramina situated at the point where the external and internal iliac veins unite.

The foramina in each instance were complete, and, as in the case of the arteries, the nerves were easily dissected away without injuring the veins.[2]

[1] *Anat. Anz.*, Bd. xi, p. 717.

[2] Ogle (*Journ. of Anat. and Phys.*, vol. xxix) describes a case as occurring in man, in which the left hypoglossal nerve pierced the wall of the left vertebral artery.

It is well known that the perforation of a vein by an artery or nerve is not, by itself, of unusual occurrence, but that it should occur with such frequency in the domestic cat, and in connection with so many other abnormalities, is deemed by the writer as worthy of mention, as it further emphasizes the unstable condition of the veins in the lumbar and pelvic regions.

Whatever the cause may be which has produced this type of abnormality, it is probably the same for both nerve and artery, and, Treadwell says, "may be referred back to the origin of the vessels in the embryo, where an interference between the formative cells of the artery and those of the vein has resulted in a penetration of one by the other."

It seems worthy of emphasis to note, in this connection, that in each instance it is the vein which is perforated and never the artery.

5. DOUBLE VEINS WHERE ONE IS NORMALLY PRESENT. — This type of abnormality is, likewise, of fairly common occurrence, and is only mentioned to further emphasize the frequency of venous abnormalities in the regions in question.

In seven instances veins which are usually single were paired, and with one exception, Fig. 1 (left double ilio-lumbar veins, 6), this duplicity occurred in connection with the veins of the right side.

Four of the above-mentioned cases refer to the renal veins and three to the ilio-lumbar.

In one case, Fig. 8 (6), the right ilio-lumbar vein (*V. ilio-lumbalis dextra*) opened into the postcava (1) by two veins, but laterad of the postcava the two veins were fused together, and through the cleft thus formed the right ilio-lumbar artery (15) passed.

The question might be asked, — Is the manner in which this cleft is formed, in any sense, comparable with that of the foramina mentioned above in connection with the postcava and common iliac veins?

It seems probable to the writer, since the foramina in the common iliac veins are located near the point of union of two veins, that these foramina may have been formed as the result

of a secondary union of the veins behind the artery or nerve which passes between them.

As previously stated, the lumbar artery, which, in two cases, was found to penetrate the postcava, was the one situated just anterior to the ilio-lumbar veins. In the case represented by Fig. 7, this artery (19) lies between the common iliac veins, near their point of union. If in this instance the veins should fuse behind the artery, a foramen would be formed which resembles in every respect the two met with in the postcava.

So far as could be ascertained by the writer, the number of abnormalities of the arterial system, in general, was small. This was also the case with the veins of the neck and fore-limb regions, which in no way approximated those found in connection with the postcava and its tributaries.

The arterial abnormalities were chiefly confined to the ilio-lumbar and iliac arteries, an example of the latter being figured below (Fig. 9).

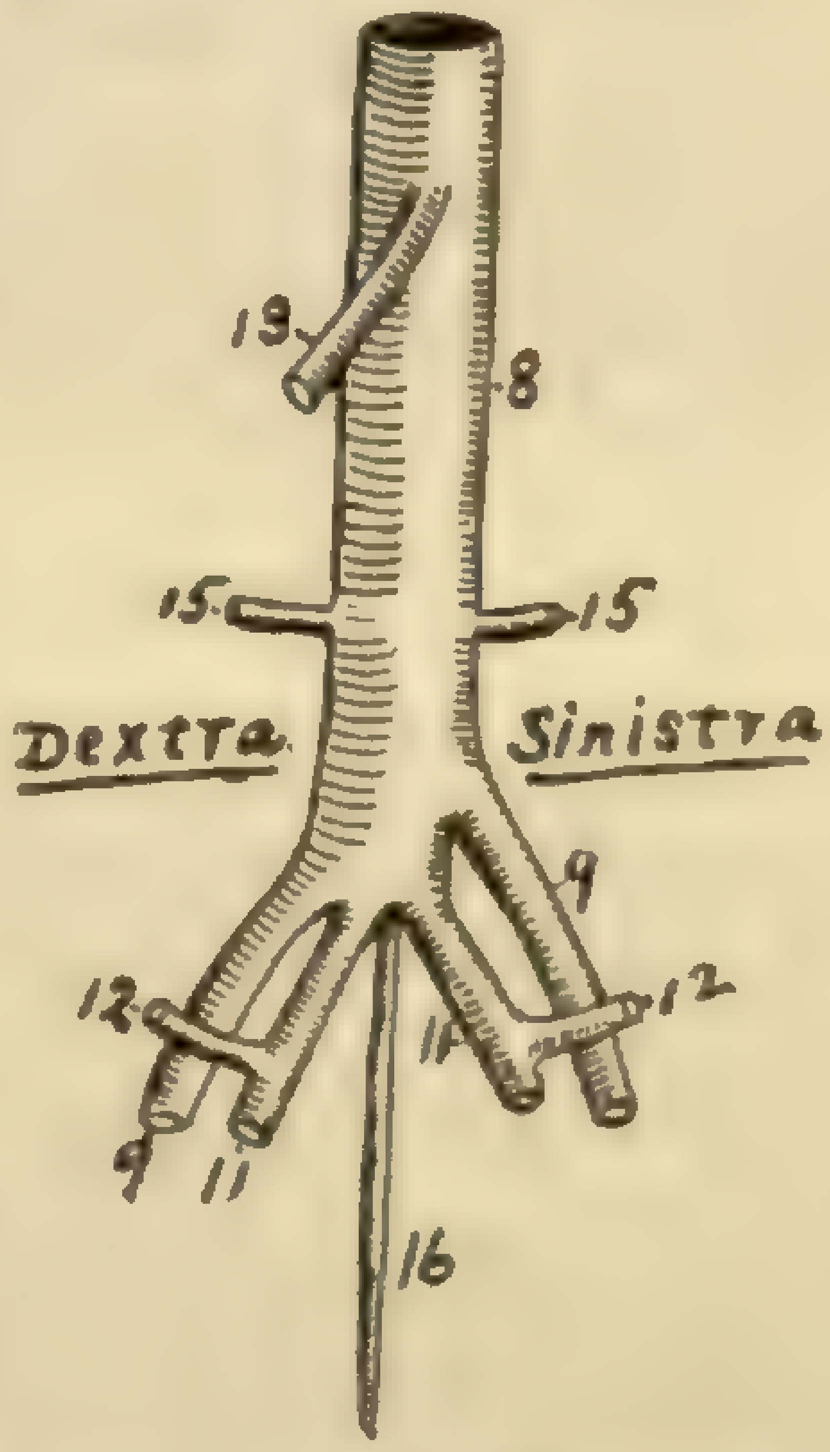

FIG. 9. — Princeton Morphological Museum, No. 607. Abnormal mode of origin of *Aa. iliacæ*. Ventral aspect. 13. *A. mesenterica post.* For remaining numbers, see Fig. 1.

One conclusion which may be drawn from a perusal of the preceding pages is that, in the cat, the veins of the lumbar and pelvic regions appear to be more liable to variation than those of any other region of the body. Whether this variation may be the result, as some might maintain in virtue of the shifting character of the lumbar vertebra, of a general instability of this region is an open question.

The greater frequency, however, with which abnormalities of the postcava and its tributaries occur, whatever the causes may be which produce them, may possibly be explained on the following grounds: The veins of the lumbar and pelvic regions possess a marked primitive arrangement in the embryo, which differs from that of the adult. In the transition from the embryonic to the adult condition, the veins, on account of the changes which they have to undergo, thus readily lend themselves to variations when, for any cause, their normal development is interrupted.

It is without the purpose of this paper to discuss the causes which are responsible for the production of venous abnormalities. It seems fair to assume, however, that any cause which may disturb the character of the normal stimuli that control the development of an organism may correspondingly influence the veins, by either arresting, accelerating, or even annulling their development.

Such causes, the effects of which undoubtedly influence these normal stimuli, must be numerous, and among others the following might be mentioned: Domestication, inbreeding, disease, drugs, and shock.

It seems, therefore, reasonable to assume that breeding experiments, carried out on these lines, might give us some clue as to the direct causes, as well as the relation of cause and effect, which are responsible for the production of abnormalities of the vascular system.

PRINCETON, N. J., January, 1900.

THE NORTH-AMERICAN JUMPING MICE.

J. A. ALLEN.

THE jumping mice of North America form a peculiar group, restricted, with one exception, so far as now known, to the middle and northern parts of North America, ranging from North Carolina, Missouri, New Mexico, and central California, northward to Labrador, Great Slave Lake, and the Yukon River. They are a little larger than the common house mouse, with very long hind legs and a very long tail. They are yellowish brown above and white below, the color of the dorsal and ventral areas being sharply separated by a broad lateral line of bright yellowish orange. They generally prefer moist meadows, marshy thickets, and the edge of woodland, but some species frequent deep forests, near streams. They are thus necessarily local in distribution, and not generally abundant, and being apparently nocturnal in habits are not often met with. They also pass the severer parts of the winter in hibernation. Opinion seems to be divided in reference to whether they constitute a distinct family type, or merely form a well-marked subfamily of the Old World Dipodidæ, or Jerboas, with which they were formerly associated generically by early writers, and of which they may be considered the American representatives. They were first generically separated from the Old World Jerboas by Coues in 1875, under the name Zapus, which he considered to represent also a distinct family, Zapodidæ.

The members of this genus greatly resemble each other in size and color; so much so that, with the scanty and imperfect material then available for study, Baird, in 1857, and Coues, in 1877, recognized only a single species. A second was made known by Miller in 1891, and a third by Allen in 1893, while during the following six years some twenty additional species and subspecies were added. Mr. Edward A. Preble, assistant in the United States Biological Survey, has recently made a

revision of the group,[1] recognizing three subgenera, twelve species, and nine additional subspecies, of which two subgenera, three species, and five subspecies are characterized as new. One of the species, and the only non-American species known, is the *Zapus setchuanus*, from Szechuen, China, the type and sole representative of Preble's new subgenus. Eozapus. The molar pattern, as figured by Preble, is, however, so different in this type from that of the American forms of Zapus that it seems well entitled to full generic rank. The twenty American forms are separated into two subgenera, Zapus proper and Napæozapus, the latter differing from the former mainly in the absence of the minute upper premolar always found in Zapus. Napæozapus comprises the single species, *Z. insignis*, described by Miller in 1891, with its subspecies abietorum and roanensis. The *Z. insignis* group, characterized among other features by a white-tipped tail, in contrast with the species of Zapus, is an Eastern type, described originally from New Brunswick, and since found to range southward, in the Canadian fauna, to the mountains of North Carolina, where it forms Mr. Preble's subspecies roanensis, and westward to the north shore of Lake Superior, where it constitutes the same author's subspecies abietorum.

These subtractions leave seventeen forms — ten species and seven subspecies — in the restricted subgenus Zapus, which collectively cover the whole of the North American range of the genus Zapus, the subgenus Zapus being found throughout the range of Napæozapus as well as elsewhere.

As already said, only one species, *Zapus hudsonius*, was recognized prior to the description of *Z. insignis* Miller in 1891, but of course many other forms were confounded under this name; but even now in its restricted sense, or as defined by Preble, it has, including its four well-marked subspecies, by far the most extensive range of any member of the genus, being found from the southern shore of Hudson Bay southward to New Jersey and in the mountains to North Carolina, and westward to Iowa and Alaska.

[1] Preble, Edward A., assistant in Biological Survey. Revision of the Jumping Mice of the Genus Zapus, *North American Fauna*, No. 15, Aug. 8, 1899, pp. 1–41, 1 plate and 3 text-figures.

Mr. Preble, in this revision of the group, has done a good piece of work in seemingly a very acceptable manner, he having had at his command practically all of the material available in our museums and private collections, including the types of all of the recently described forms, the specimens examined by him numbering nearly one thousand.

Of the thirty specific and subspecific names applied to members of this group, seven of the nine synonyms are referred to the long known *Zapus hudsonius*. A list of the species and subspecies recognized by Mr. Preble here follows, with a brief statement of their ranges, so far as known, based on Mr. Preble's excellent paper. Much still remains to be learned about the group, especially in respect to the geographical distribution of most of the forms, but a good foundation has been laid on which to build the final superstructure.

Subgenus Zapus.

1. *Zapus hudsonius* (Zimmermann). Type locality, Hudson Bay. From Hudson Bay south to New Jersey and in the mountains to North Carolina; west to Iowa and Great Slave Lake. (Includes *Z. h. canadensis* Batchelder and *Z. h. hardyi* Batchelder.)

1 *a*. *Zapus hudsonius ladas* Bangs. Eastern Quebec, north to Hamilton Inlet, Labrador.

1 *b*. *Zapus hudsonius americanus* (Barton). Vicinity of Raleigh, N. C., north along the coastal plain to southern Connecticut and the lower Hudson valley.

1 *c*. *Zapus hudsonius campestris* Preble. Great Plains, from Manitoba to Nebraska, and northeastern Colorado, west over eastern Wyoming.

1 *d*. *Zapus hudsonius alascensis* Merriam. Yakutat Bay, north to Yukon River.

2. *Zapus tenellus* Merriam. Known only from vicinity of Kamloops, B. C.

3. *Zapus princeps* Allen. Rocky Mountain region, from New Mexico to northern Alberta.

3 *a*. *Zapus princeps minor* Preble. Plains of Saskatchewan.

3 *b*. *Zapus princeps oregonus* Preble. Blue Mountains of Oregon.

4. *Zapus major* Preble. Known only from the type, from Warner Mountains, Oregon.

5. *Zapus nevadensis* Preble. Known only from the type, taken in the Ruby Mountains, Nevada.

6. *Zapus trinotatus* Rhoads. Coast region, from Frazer River, B. C., to northern California. (Includes *Z. imperator* Elliot.)

6 *a.* *Zapus trinotatus alleni* Elliot. Mount Shasta and Sierra Nevada of California.

7. *Zapus montanus* Merriam. Cascade Range, Oregon.

8. *Zapus orarius* Preble. Coast of California from Point Reyes to Mendocino County.

9. *Zapus pacificus* Merriam. Rogue River Valley, Oregon, and southward into California.

10. *Zapus saltator* Allen. Northern British Columbia.

Subgenus Napæozapus.

11. *Zapus insignis* Miller. New Brunswick, northern New England, Adirondacks and Catskills of New York, and southward in the Alleghanies to Maryland.

11 *a.* *Zapus insignis roanensis* Preble. Roan Mountains, N. C.

11 *b.* *Zapus insignis abietorum* Preble. Quebec and western Ontario.

FRESH-WATER AQUARIA.

L. MURBACH.

The lover of nature, taking his early spring walks, often feels the desire to cultivate a nearer acquaintance with the living things that he sees in ponds and pools along his way. He may dip up samples here and there, taking some water weed and a string of the jelly beads containing toads' eggs, place them in glass jars or aquaria at home, and gain further pleasure, for a few days at most, and then the whole mass becomes foul and is thrown away. His ill-success is due to the improper balance between animals and to the popular misconception that an aquarium with animal life should be uncovered so that the animals can get air to breathe; and the remedy lies in keeping the aquarium, once properly balanced from one spring to another, so well covered that scarcely any evaporation of water can take place. To this then may be added new organisms from time to time.

None of the numerous notices on the keeping of aquaria that I have seen describe permanent aquaria without changing the water; yet this is one of the most desirable features — to keep the aquarium, year in year out, for observing the interesting succession of forms, often including representatives of animal groups from Protozoa to Crustacea, with an almost equal diversity of aquatic plants.

Some of the pond scum (algæ), drawn by light and adhering to the side of the glass, may be made to decorate the side of the aquarium with almost any pattern in green — letters, or your monogram if you choose. Some of my experience may be useful to the reader, and I gladly give it for what it may be worth.

Seeing the algæ in my largest aquarium accumulate on the side most strongly lighted, it occurred to me that they might be made to form a definite design by regulating the light.

First a stencil of paper or pasteboard was used, but as this was not permanent enough, one of my students, living next door to a tinsmith, cut out the monogram of our school and attached it to the outside of the aquarium, having previously cleaned the inside with a scraper. In a few weeks the letters "D. H. S." were sharply marked by the sun's ray-pencils and the microscopic green plants within. (See figure in *Journ. Applied Micros.*, July, 1899, Vol. II, No. 7.) The stencil may be removed at any time for inspection, but should be kept in position the half of each day, while the strongest light falls on the aquarium to keep the letters from being obliterated. This experiment serves to illustrate the movement of green plants towards the source of light, and has interested many of our visitors.

Such balanced aquaria also have a practical value in the schoolroom or laboratory; each one will have its own fauna, and may serve as a source of animalculæ — Amœbæ and other Protozoa so highly prized by the young teacher — and larger animals and plants for demonstration, experiment or research, in more nearly their natural environment, than those kept in water changed daily. This last spring we had a nice illustration of this fact; some fairy shrimps (Branchipus) were placed in a glass jar with water and plants of their habitat, and a few were placed in one of the balanced aquaria of the same size and receiving the same lighting. Those in the first jar died in a few days (the common experience of every one who has tried to keep them in the laboratory for demonstration), while those in the aquarium lived three times longer.

In one small aquarium jar, set up over a year ago, containing mostly diatoms, Oscillaria, some water fleas and Rotatoria, there has been a good supply of Amœbæ for class use. Another larger one, kept over two and one half years, in which a large snail, some water weed, and smaller animals constitute the balance, furnishes sun animalcules for demonstration. The largest one, with glass plate sides, slate bottom and ends, has been kept nearly two years without change or addition of water. It is stocked with aquatic plants, Cladophora, Myriophyllum, Lemna, Wolffia, Anacharis, and many single-celled algæ. The

largest animal representative is a so-called "bull-head" (one of the species of Uranidæ), about four inches long, kept principally for the balance, and because he needs no further attention than a few earthworms every few days. In this aquarium fresh-water polyps, Polyzoa, and other interesting forms appear in their season.

In speaking of the time these aquaria have been kept, it is to be understood without changing the water but covered in such a way as to require very little or no additions of water to supply evaporation.

The aëration of the water for the breathing of animals will be readily seen to come from the oxygen given out by the plants while they feed (during photo-syntax) on the carbonic acid gas given out by the animals. The only thing needing attention is the feeding of such animals as cannot find their source of food in the aquaria themselves, and this should be done so carefully that no food is left to decay.

For aquaria almost any kind of glass vessel that can be securely covered against dust and bacteria may be used — jam jars, battery jars, culture dishes and globes for the smaller window aquaria; window glass, properly cemented into wooden frames that are kept coated with paraffin or asphalt varnish, for a medium size; and slate bottom and ends, with plate-glass sides, for the larger though more expensive ones.

In setting up the aquaria it is better to begin with water from some clean pond containing considerable plant and animal life. Fill up to within a few inches of the top with water, and then add about $\frac{1}{25}$ its bulk of plants and animals; or hydrant water may be used, adding some plants, and later the animals desired. Where there is no choice, snails and Crustaceæ are the most convenient for use, unless they are hostile to the organisms desired for experiment. The snails feed on the plants, giving these carbonic acid in turn for food, while the Crustaceæ feed mostly on the débris from other organisms.

If the animals keep near the surface, too many are probably present, and some must be removed or more plants added. When the plants become yellow they are too abundant or have not had light enough. In some cases the water becomes foul

on first setting up the aquarium, and as this is one way of obtaining certain desirable results, keep it covered until the foul odor disappears, and if new plants do not appear in time, add plants and animals to suit, and it may prove to be the best aquarium you have. Marine Protozoa have been kept this way in jars brought from the seashore several years ago.

Central High School,
Detroit, Mich.

SYNOPSES OF NORTH-AMERICAN INVERTEBRATES. VIII.

THE ISOPODA. — PART I.

CHELIFERA, FLABELLIFERA, VALVIFERA.

HARRIET RICHARDSON.

THE Isopoda represent an order of Crustacea widely distributed and varying greatly in their mode of life and in their habitat. They abound not only in the sea, where they are taken in shallow water and from the greatest depths, but large numbers of them are also found in ponds and streams and other bodies of fresh water. The terrestrial Isopoda form a large and important group, and are commonly known as "pill-bugs." Many of the Isopoda live a free existence, while others are parasitic. These latter are found in the mouths and gills of fishes, in the branchial cavities of Decapoda, on Copepoda, and on other Isopoda.

In the following key the marine forms have not been limited bathymetrically. Where it has been possible, the depth from which the specimens were taken has been given. The fresh-water and terrestrial forms are included.

The lettering for the distribution of species has been adopted in accordance with what has been used in former papers of this series of synopses on marine invertebrates: *A* for Alaska south; *P* for Puget Sound to San Francisco; *D* for Monterey to San Diego; *N*, Atlantic coast south to Cape Cod; *M*, Cape Cod to North Carolina; *S*, South Carolina to Florida; *G*, Gulf of Mexico.

The literature on the Isopoda has been limited in the following list to those papers which treat especially of North American forms. The most important of these are:

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1852. DANA, JAMES D. Crustacea of the United States Exploring Expedition. Vol. i, pp. 696–805.

1853. STIMPSON, WM. Synopsis of the Marine Invertebrata of Grand Manan, Smithsonian Contributions to Knowledge. Vol. vi.

1854. DANA, JAMES D. Catalogue and Descriptions of Crustacea collected in California by Dr. John Le Conte. *Proc. Acad. Nat. Sci. Philadelphia.* Vol. vii, pp. 175–177.

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1866. BATE, SPENCE. In Lord's "Naturalist in British Columbia." Pp. 281–284.

1874. VERRILL, A. E., and SMITH, S. I. Report upon the Invertebrate Animals of Vineyard Sound. *Rept. U. S. Fish Comm. for 1871–1872.*

1875. STUXBERG, A. Om Nord-Amerikas Oniscider. *Ofversigt af Vetensk. Akad. Forhandl.*, No. 2.

1877. HARFORD. Description of a New Genus and Three New Species of Sessile-Eyed Crustacea, pp. 54, 55, and Descriptions of Three New Species of Sessile-Eyed Crustacea, with Remarks on Ligia occidentalis, pp. 116, 117. *Proc. California Acad. Sci.* 1876. Vol. vii.

1877. LOCKINGTON, W. N. Remarks on the Crustacea of the Pacific Coast, with Descriptions of Some New Species, p. 36, and Descriptions of Seventeen New Species of Crustacea, pp. 44–46. *Proc. California Acad. Sci.* 1876. Vol. vii.

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1883. HARGER, OSCAR. Reports on the Results of Dredging, under the Supervision of Alexander Agassiz, on the East Coast of the United States, during the Summer of 1880, by the U. S. Coast Survey Steamer *Blake*, Commander J. R. Bartlett, U. S. N., commanding. *Bull. Mus. Comp. Zoöl., Harvard College.* Vol. xi, No. 4, pt. xxiii.

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1898. BENEDICT, JAMES E. The Arcturidæ in the U. S. Nat. Museum. *Proc. Biol. Soc. Washington.* Vol. xii, pp. 41–51.

1898. BENEDICT, JAMES E. Two New Isopods of the Genus Idotea from the Coast of California. *Proc. Biol. Soc. Washington.* Vol. xii, pp. 53–55.

1898. WALKER, ALFRED O. Crustacea Collected by W. A. Herdman in Puget Sound, Pacific Coast of North America. *Trans. Liverpool Biol. Soc.* Vol. xii, pp. 279–281.

1898. Calman, W. T. On a Collection of Crustacea from Puget Sound. *Ann. New York Acad. Sci.* Vol. xi, No. 13, pp. 274–282.

1899. Richardson, Harriet. Key to the Isopods of the Pacific Coast of North America, with Descriptions of Twenty-two New Species. *Proc. U. S. Nat. Mus.* Vol. xxi, pp. 815–869.

1900. Richardson, Harriet. Key to the Isopoda of the Atlantic Coast of North America, with Descriptions of New Species. (In manuscript, to be published later.)

In addition to those mentioned, the works of G. O. Sars, H. J. Hansen, Schiœdte and Meinert, Stebbing and Budde-Lund, have been of much assistance in the compilation of this key.

Synopsis of the Isopoda.

a. Legs of the first pair cheliform. Uropoda terminal. Pleopoda, when distinctly developed, exclusively natatory. . . . . I. Chelifera

a′. Legs of the first pair not cheliform.

- *b.* Uropoda lateral.
  - *c.* Uropoda forming together with the terminal segment of the abdomen a caudal fan. Pleopoda for the most part natatory. . . . . II. Flabellifera
  - *c′.* Uropoda valve-like, inflexed, arching over the pleopoda, which, to a great extent, are branchial. III. Valvifera
- *b′.* Uropoda terminal.
  - *c.* Free forms.
    - *d.* Pleopoda exclusively branchial, generally covered by a thin opercular plate (the modified first pair). IV. Asellota
    - *d′.* Pleopoda fitted for air-breathing. . V. Oniscoidea
  - *c′.* Parasitic forms. Pleopoda, when present, exclusively branchial in the adult form, and not covered by any operculum. VI. Epicaridea

I. Chelifera.

a. Body scarcely attenuated behind. Mandibles without palp. Anterior maxillæ with only a single masticatory lobe and a one-jointed palp ; posterior ones quite rudimentary. Epignath of maxillipeds narrow, falciform. Superior antennæ with one multi-articulate flagellum. Second pair of legs ambulatory in character. . Family I. Tanaidæ

a′. Body narrow, produced, depressed. Mandibles with a three-jointed palp. Anterior maxillæ with two masticatory lobes and a two-jointed palp ; posterior ones well developed and setose. Epignath of maxillipeds large, laminar, branchial in character. Superior antennæ with two multi-articulate flagella. Second pair of legs with a large, broad, flat hand, for burrowing purposes. . Family II. Apseudidæ

FAMILY I. TANAIDÆ.

a. Pleopoda only three pairs. Uropoda simple, short, single-branched.
Tanais Audouin and Edwards

a′. Pleopoda five pairs. Uropoda double-branched.

b. Eyes wanting.

c. Inner branch of uropoda two to three-jointed. Pleopoda in female very small or rudimentary.

d. Incubatory pouch formed only by two lamellæ issuing from bases of fourth pair of legs. Pleopoda in female rudimentary. Gnathopods alike in both sexes. Mandibles well developed, with cutting edge coarsely dentated. . . . . . . Cryptocope G. O. Sars

d′. Incubatory pouch normal. Pleopoda in female small, sometimes wanting. Gnathopods in female of normal appearance, hand dilated, fingers strong, thumb serrulated, in male slender, fingers simple. Mandibles very small and feeble in structure, with cutting edge narrow. . . . . Leptognathia G. O. Sars

c′. Inner branch of uropoda eight to nine-jointed. Pleopoda well developed. . . Aloatanais Norman and Stebbing

b′. Eyes present.

c. Gnathopods in male imperfectly chelate, without any finger, or with finger very short and immovable.
Heterotanais G. O. Sars

c′. Gnathopods in male with chelæ fully developed.

d. Gnathopods in male sometimes very much elongated, with carpus attenuated, hand very large, oblong, finger elongate and curved, immovable, strongly tuberculate within. Thoracic appendages not specialized into an anterior and a posterior series. Marsupium of female formed of eight large lamellæ from the four first free segments.
Leptochelia Dana

d′. Gnathopods in male with chelæ very stout, the distal section of the penultimate joint extremely broad, with a toothed margin. Thoracic appendages specialized into an anterior and a posterior series. Marsupium of the female of the normal structure.
Neotanais Beddard

Genus Tanais Audouin and Edwards.

a. Periopoda having the first three joints short and broad, dilated and affixed to the sides of the thorax like plates of mail.
Tanais loricatus Spence Bate, *A*, 10 fms.

a′. Periopoda, with joints not dilated, slender.

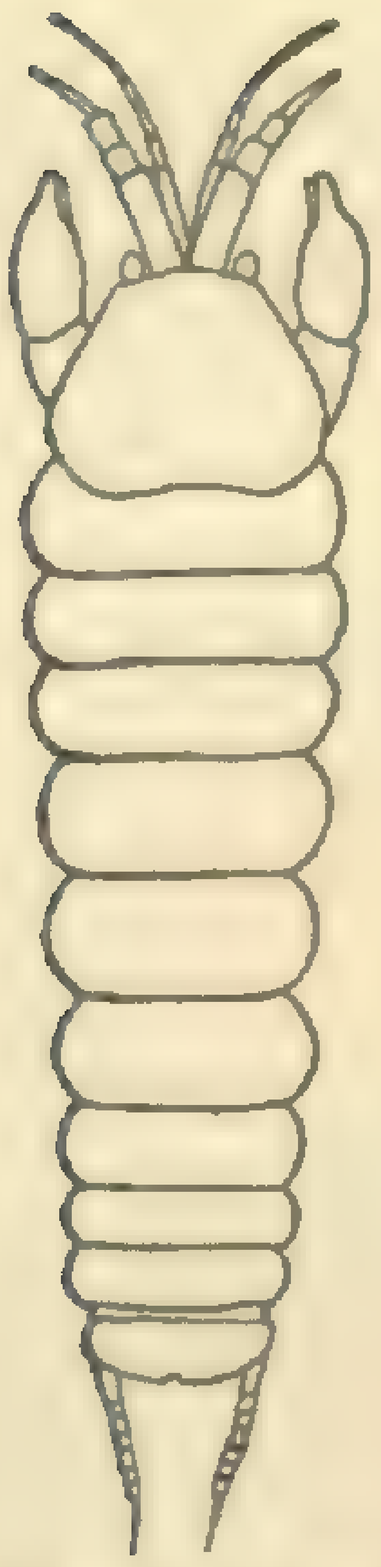

Fig. 1. — *Tanais alascensis.*

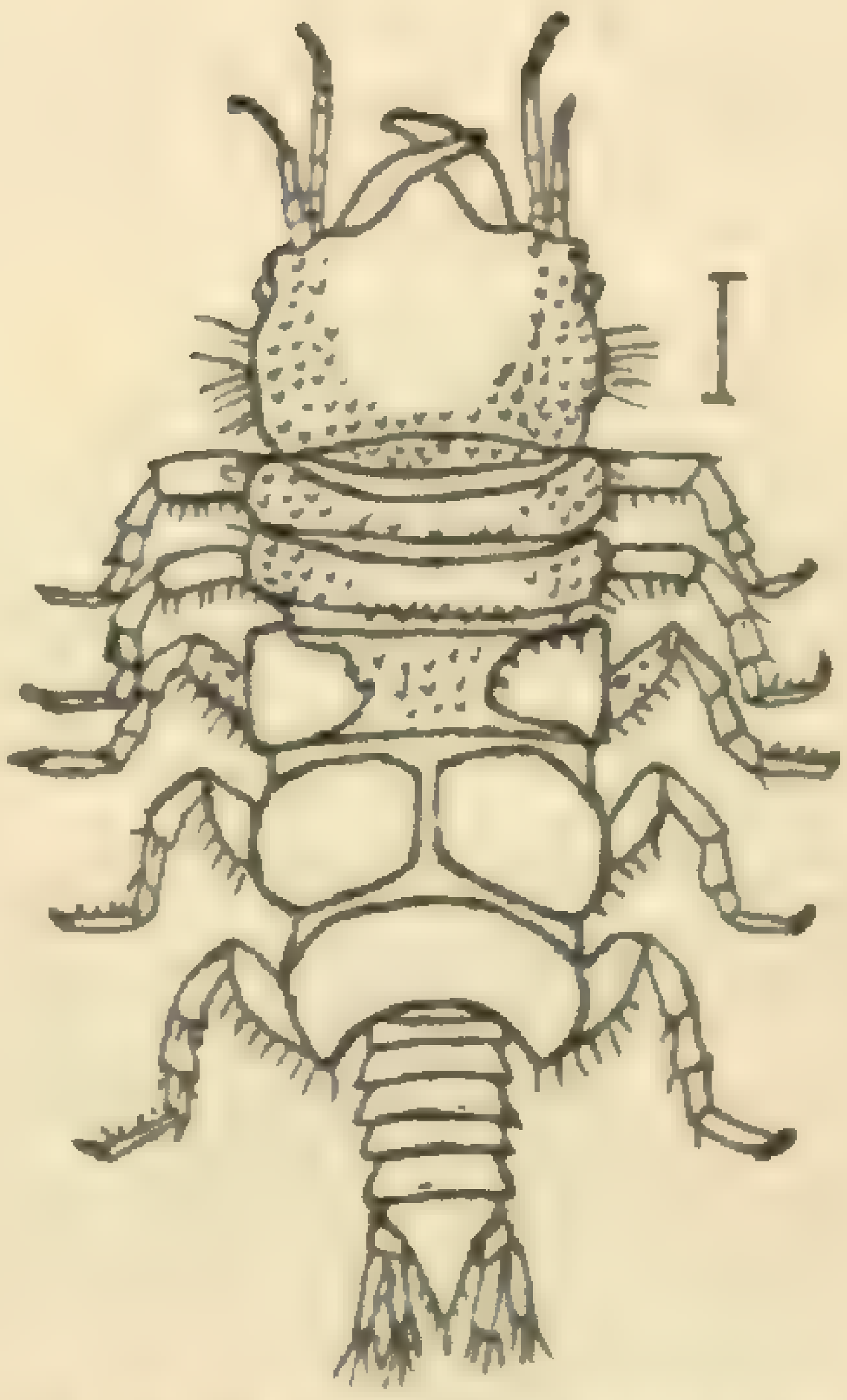

Fig. 2.[1] — *Gnathia cerina.*

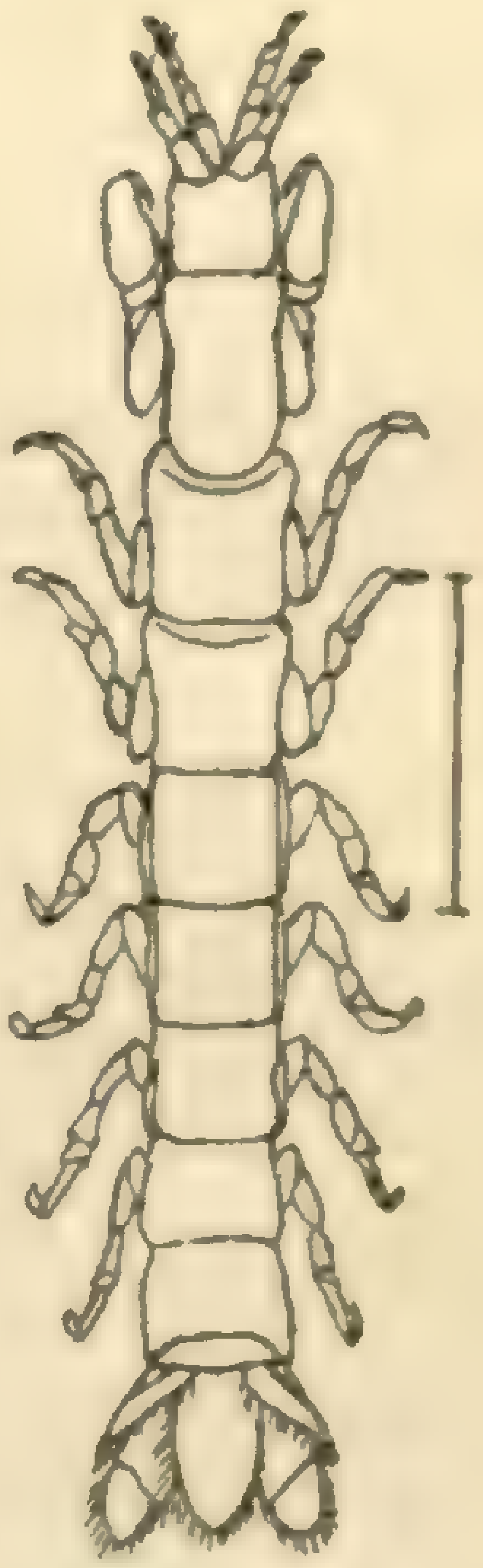

Fig. 3.[1] — *Cyathura carinata.*

b. Abdomen composed of six segments. Body robust and tapering.
Tanais robustus Moore, *M*

b′. Abdomen composed of five distinct segments. Body slender, elongated.

c. With transverse setiferous bands crossing first and second abdominal segments. Terminal segment with a blunt median projection. Uropoda three-jointed.
Tanais cavolinii Milne Edwards, *N*

c′. Without transverse setiferous bands crossing first and second abdominal segments. Terminal segment with slight median notch. Uropoda seven-jointed.
Tanais alascensis Richardson, *A*, 6–8 fms.

Genus Cryptocope G. O. Sars. . *Cryptocope arctica* Hansen, *N*, 170 fms.

Genus Leptognathia G. O. Sars.

a. In female inner branch of uropoda twice as long as outer. The second or first free segment of thorax is about two-thirds as long as the third, which in turn is about equal to the fourth and fifth. Sixth and seventh segments are progressively somewhat shorter. Propodus of first pair of legs less robust than carpus.
Leptognathia cæca (Harger), *N*, surface to 48 fms.

a′. In female inner branch of uropoda more than three times as long as outer. The second, or first free segment of thorax about same size as the last one, both being shorter than the others. Propodus of first pair of legs scarcely smaller than carpus.
Leptognathia longiremus (Lilljeborg), *N*, 35–40 fms.

[1] Figures taken from O. Harger.

Genus Aloatanais Norman and Stebbing.

Aloatanais hastiger Norman and Stebbing, *N*, 1750 fms.

Genus Heterotanais G. O. Sars. *Heterotanais limnicola* Harger, *N*, 48 fms.

Genus Leptochelia Dana.

a. Gnathopods in male greatly elongated, with tuberculate immobile finger. Upper antennæ three-jointed, with rudimentary flagellum in female, much more elongated, and with a multi-articulate flagellum in male.

b. Inner branch of uropoda five-jointed. Antennulæ, with basal segment nearly one-half length of the whole organ, are more than one-third as long as the body.

Leptochelia rapax Harger, *N*, one-half fm.

b'. Inner branch of uropoda six-jointed. Antennulæ, with basal segment about one-third length of the whole organ, are about two-thirds as long as body.

Leptochelia savignyi (Krøyer), *N*, surface

a'. Gnathopods in male not greatly elongated. Upper antennæ three-jointed, not elongated in male.

b. Inner branch of the uropoda five-jointed. Terminal abdominal segment rounded behind.

Leptochelia (?) *filum* (Stimpson), *N*, 8 fms.

b'. Inner branch of the uropoda six-jointed. Terminal abdominal segment pointed posteriorly.

Leptochelia dubia (Krøyer), *N*, surface to one-half fm.

Genus Neotanais Beddard. *Neotanais americanus* Beddard, *M*, 1240 fms.

FAMILY II. APSEUDIDÆ.

a. Lower antennæ with a scale articulated to the end of the second joint. First free segment of the thorax with epimera conspicuous, spine-formed, porrected. First five pair of pleopoda with both branches usually one-jointed. Exopods on both pairs of gnathopods.

Apseudes Leach

a'. Lower antennæ without a scale. Carapace composed of head and two following segments coalesced. . Sphyrapus Norman and Stebbing

Genus Apseudes Leach.

Apseudes gracilis Norman and Stebbing, *N*, 1750 fms,

Genus Sphyrapus Norman and Stebbing.

Sphyrapus malleolus Norman and Stebbing, *N*, 1450 fms.

II. FLABELLIFERA.

a. Legs in the adult in six, apparently only in five pairs.

Family III. Gnathiidæ

a'. Legs in the adult in seven pairs.

b. Uropoda lateral and superior, outer branch arching over base of telson. Body cylindrical, narrow, elongated.

Family IV. Anthuridæ

b′. Uropoda lateral.

c. Abdomen consisting of six segments.

d. Uropoda with both branches developed; mostly lamelliform.

e. Maxillipeds with the palp free, the margins of the last two joints more or less setose, never furnished with hooks.

f. Mandibles with the distal half stout, very conspicuous, uncovered, or with only the anterior margin concealed; from the base towards the middle directed forwards and a little outwards.

g. Mandibles with the rather broad, more or less tridentate, cutting edges meeting squarely behind the large upper lip; the secondary plate and peculiar equivalent for the molar well developed. First maxillæ having the plate of the first joint armed with three spines, that of the third with many. Second maxillæ of moderate size, the three free plates very setose. Maxillipeds with the palp rather broad, very setose.

Family V. Cirolanidæ

g′. Mandibles with the distal part produced into a long prominent process, the pair much overlapping; the secondary plate and molar evanescent. First maxillæ having the plate of the first joint unarmed, of the third, carrying one very long spine. Second maxillæ small and feeble, the free plates almost rudimentary, with few setæ. Maxillipeds with the palp narrowed, not very setose.

Family VI. Corallanidæ

f. Mandibles with the distal half narrow, most or all of it concealed by the upper and lower lips; from the base towards the apex directed gradually inwards.

Family VII. Alcironidæ

e′. Maxillipeds with the palp embracing the cone formed by the distal parts of the mouth organs,

the inner upper margin and apex never setose, the apex and sometimes the inner upper margin, at least in the males and females without eggs, being furnished with outward curved hooks.

f. Mandibles with the secondary plate very often visible ; palp with no inflated joint. Maxillipeds commonly seven-jointed, sometimes four-jointed, the last joint in the latter case rather short, obtuse. Antennæ long, unequal, with well-defined peduncle and flagellum. . . . . . Family VIII. Ægidæ

f′. Mandibles with no secondary plate ; the palp in adults with first joint or both first and second joints inflated. Maxillipeds always four-jointed, last joint rather long and narrow, subacute. Antennæ much reduced without clear distinction between peduncle and flagellum. Family IX. Cymothoidæ

d′. Uropoda with one of the branches almost obsolete or rudimentary — not lamelliform.

Family X. Limnoriidæ

c′. Abdomen consisting of less than six segments.

d. Abdomen with two segments. Uropoda with one branch fixed, immovable. Family XI. Sphæromidæ

d′. Abdomen with four segments. Uropoda with both branches movable. . . . Family XII. Serolidæ

FAMILY III. GNATHIIDÆ.

Genus Gnathia Leach.

a. Mandibles in male with the basal part ornamented on the superior margin with an elevated crest, which is irregularly dentate. Legs furnished with many spiny processes. *Gnathia cristata* (Hansen), *N*, 116 fms.

a′. Mandibles in male without elevated crest on the superior margin. Legs without spiny processes.

b. Mandibles in male with slight notch outside, inner edge obtusely produced in the middle, tip acute, slightly incurved. Front of head not produced in the middle beyond the antero-lateral angles. . . . . *Gnathia elongata* (Krøyer), *N*

b′. Mandibles in male carinate on outer side near the middle, the carina ending in a tooth-like process, irregularly and bluntly toothed near the base within, turned upward at apex. Front of head produced in the middle much beyond the antero-lateral angles.

Gnathia cerina (Stimpson), *N*, 10–220 fms. (See Fig. 2, p. 211.)

Family IV. Anthuridæ.

a. Labium terminating in two rounded lobes. Mandibles with cutting edge of two or three blunt teeth, and a semicircular saw in place of molar and spine row; palp three-jointed. First maxillæ simple, with apical teeth. Maxillipeds with three to six broad, flattened joints.

b. First five segments of the abdomen coalesced into a single segment in the female.

c. Maxillipeds three-jointed. Flagella of both pairs of antennæ few jointed in female; of first multi-articulate in male. Anthura Leach

c′. Maxillipeds four-jointed. Flagella of both pairs of antennæ rudimentary, of the first pair not greatly developed in the male. . . . . Cyathura Norman and Stebbing

b′. Segments of abdomen distinct. Maxillipeds six-jointed. Anthelura Norman and Stebbing

a′. Labium terminating in two points, acuminate. Mandibles without teeth, lancet-like, lobes at base forming channel. First maxillæ spear-like, distally channeled and serrate. Maxillipeds elongate, with four to five joints, the second of which is elongate. Abdomen with six segments and caudal segment distinct. Antennæ in both sexes with many jointed flagella. Calathura Norman and Stebbing

Genus Anthura Leach. *Anthura tenuis* (Harger), *N*, surface to 19 fms.

Genus Cyathura Norman and Stebbing.

Cyathura carinata (Krøyer), *NM*, surface to 19½ fms. (See Fig. 3, p. 211.)

Genus Anthelura Norman and Stebbing.

Anthelura abyssorum Norman and Stebbing, *N*, 1750 fms.

Genus Calathura Norman and Stebbing.

Calathura branchiata (Stimpson), *N*, 20–200 fms.

Family V. Cirolanidæ.

a. Peduncle of the second antennæ five-jointed. Plate of the second joint of the maxillipeds furnished with hooks.

b. Eyes present. Uropoda with the inner angle of the peduncle produced.

c. First and second pairs of pleopoda equal in length, with at least the inner branch submembranaceous. Cirolana Leach

c′. First pair of pleopoda with both branches hard, and forming a large operculum. Second pair of pleopoda submembranaceous. . . . . Conilera Leach

b′. Eyes wanting. Uropoda with the inner angle of the peduncle not produced. . . . . Cirolanides Benedict

a′. Peduncle of second antennæ four-jointed. Plate of second joint of maxillipeds without hooks. Uropoda with inner angle of peduncle very little produced. Pleopoda with both branches submembranaceous. Superior antennæ with first joint of peduncle quite short, and extended straight in front at a right angle to remaining part of the antenna. . . . . Eurydice Leach

Genus Cirolana Leach.

a. Fifth abdominal segment with lateral angles free, not covered by the fourth segment. . . . *Cirolana linguifrons* Richardson, *D*, surface

a′. Fifth abdominal segment with lateral angles covered by fourth segment.

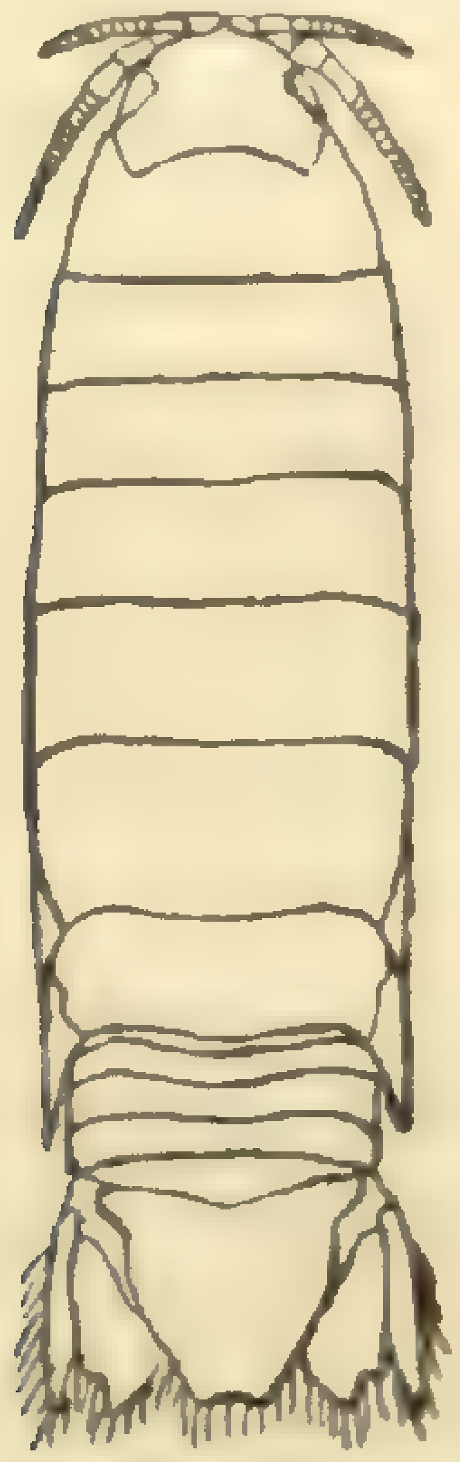

Fig. 4.[1] — *Cirolana concharum.*

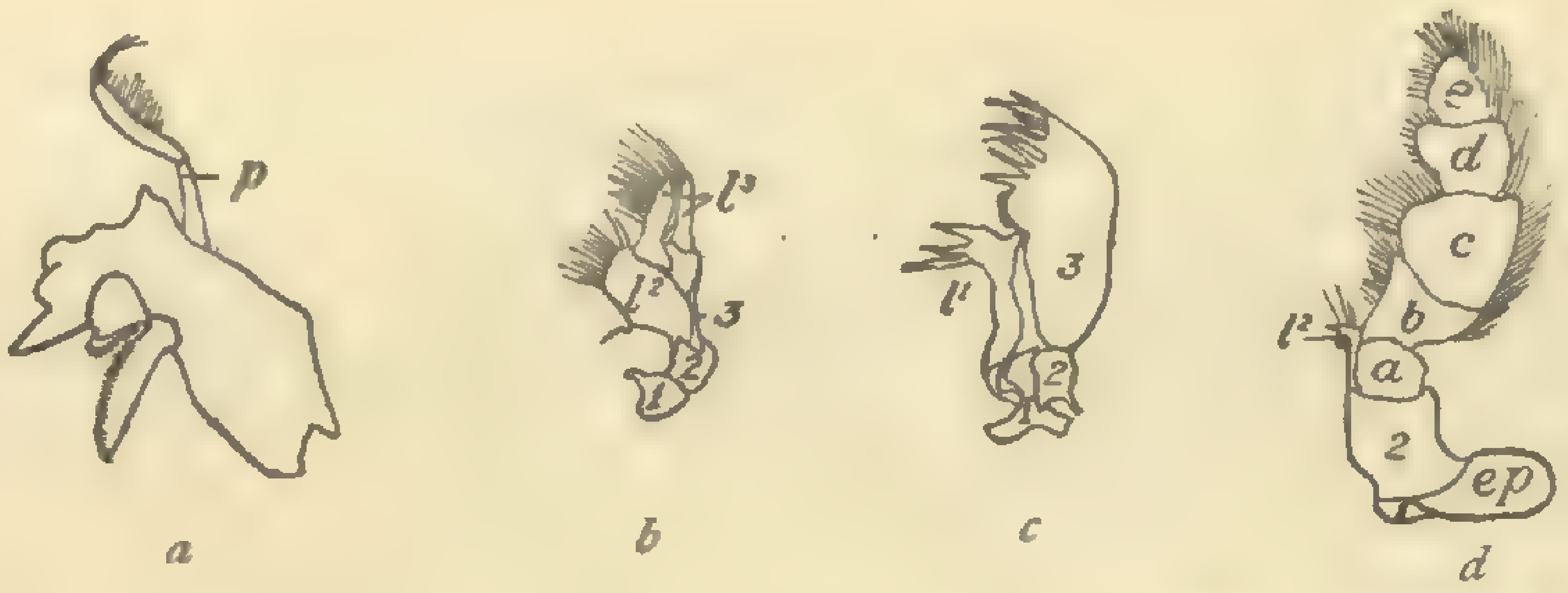

Fig. 5.[1] — *a*, Mandible of *Cirolana borealis*; *p*, palpus. *b*, Maxilla of the second pair; *1*, first joint; *2*, second joint; l^2, lobe of the second joint; *3*, third joint; l^3, lobes of the third joint. *c*, Maxilla of the first pair; *1*, first joint; l^1, lobe of the first joint; *2*, second joint; *3*, third joint. *d*, Maxilliped; *1*, first joint; *ep.*, epignath; *2*, second joint; l^2, lobe of the second joint; *a*, *b*, *c*, *d*, *e*, palpus.

b. Frontal lamina posteriorly or clypeus anteriorly produced horn-like, especially so when seen from the side.

Cirolana virginiana Richardson, *M*, 81 fms.

b′. Frontal lamina and clypeus unarmed, not produced horn-like; anterior margin of the clypeus connected with the frontal lamina.

c. Frontal lamina narrow, elongate, four to six times longer than broad.

d. Extremity of exterior margin of inner branch of the uropoda emarginate.

e. Terminal segment emarginate at its extremity.

Cirolana concharum (Stimpson), *NM*, surface to 18 fms.

e′. Terminal segment not emarginate at its extremity.

Cirolana impressa Harger, *M*, 115–321 fms.

d′. Extremity of exterior margin of inner branch of the uropoda not emarginate.

e. Second pair of antennæ long, extending beyond the posterior margin of the third thoracic segment. *Cirolana borealis* Lilljeborg, *S*, 233 fms.

[1] Figures taken from Hansen.

e'. Second pair of antennæ short, reaching to the middle of the first thoracic segment.

Cirolana polita Harger, *N*, 17–190 fms.

c'. Frontal lamina broad, short, scarcely twice as long as wide.

d. Terminal segment with the posterior margin armed with many (twenty-six) robust spines. Branches of uropoda with apex rounded.

Cirolana harfordi (Lockington), *APD*, surface to 40 fms.

d'. Terminal segment with the posterior margin armed with a few slender spines. Branches of uropoda with apex acute.

Cirolana parva Hansen, *G*, 25–27 fms.

Genus Conilera Leach.

Conilera cylindracea (Montague), *SG*, 111–159 fms.

Genus Cirolanides Benedict.

Cirolanides texensis Benedict, Texas, fresh-water

Genus Eurydice Leach.

a. Second pair of antennæ in male extend to the posterior margin of fourth abdominal segment; flagellum consists of twenty-five joints. Terminal segment truncate between the post-lateral teeth.

Eurydice caudata Richardson, *D*

a'. Second pair of antennæ in male extend the entire length of the body; flagellum consists of eighteen joints. Terminal segment rounded between the post-lateral teeth. . *Eurydice convexa* Richardson, *G*

Family VI. Corallanidæ.

Genus Corallana Dana. . . . . . *Corallana truncata* Richardson, *D*

Family VII. Alcironidæ.

Genus Alcirona Hansen. . . . *Alcirona krebsii* Hansen, *G*, 25–28 fms.

Family VIII. Ægidæ.

a. Body rather compact. Superior antennæ short, with first two peduncular joints more or less expanded. Epistome large, linguiform, projecting between the bases of inferior antennæ. Maxillipeds with palp composed of five joints. Front separating the whole or a great part of the first article of the first pair of antennæ. Flagellum of the first pair of antennæ composed of many joints. Abdomen compact . . . . Æga Leach

a'. Body depressed. Superior antennæ short, with basal joints not expanded. Epistome very small and narrow. Maxillipeds with palp composed of only two joints. Front covering more or less the

peduncle of the first pair of antennæ. Flagellum of first pair of antennæ composed of four to six joints. Abdomen relaxed.

b. Eyes present. Anterior pairs of legs with propodus more or less expanded, dactylus forming a very large and evenly curved hook. Mandibles with the cutting edge expanded inside to a linguiform lamella ; palp well developed, with basal joint much elongated. Abdomen not much narrower than thorax. Rocinela Leach

b′. Eyes wanting. Anterior pairs of legs with propodus not expanded, dactylus abruptly curved in the middle, and terminating in a very sharp point. Mandibles with the cutting edge simple, acuminate ; palp of moderate length. Abdomen narrowing abruptly to a much smaller width than the thorax ; terminal segment very large. . . . . Syscenus Harger

Genus Æga Leach.

a. Peduncle of the first pair of antennæ plane or concave, joints fitting into each other. Frontal lamina plane or concave.

b. Terminal segment of body pointed at extremity. Eyes distant. *Æga psora* (Linn), *N*, 30–218 fms.

b′. Terminal segment of body not pointed at extremity.

c. Terminal segment posteriorly bisinuate. Surface of segment smooth, without carinæ. *Æga ecarinata* Richardson, *G*, 88 fms.

c′. Terminal segment emarginate or truncate.

d. Terminal segment emarginate. Eyes distant. *Æga webbii* Gúerin, *S*, 333 fms.

d′. Terminal segment truncate.

e. Eyes contiguous. Propodus of the posterior prehensile legs with a cultriform lamina. *Æga crenulata* Lütken, *N*

e′. Eyes not contiguous. Propodus of posterior prehensile legs without cultriform lamina. *Æga lecontii* (Dana), *D*

a′. Peduncle of the first pair of antennæ well rounded and with joints compressed. Frontal lamina convex or compressly elevated.

b. Eyes contiguous. Terminal segment incised. *Æga incisa* Schiœdte and Meinert, *S*, 263–440 fms.

b′. Eyes not contiguous.

c. Terminal segment linguate, incised posteriorly. *Æga arctica* Lütken, *N*.

c′. Terminal segment triangular, entire.

d. Terminal segment, with apex rounded. *Æga microphthalma* Dana, *D*

d′. Terminal segment, with apex produced. *Æga ventrosa* Sars, *N*, 120 fms.

Genus Rocinela Leach.

a. Eyes contiguous. Head produced into process in front.
Rocinela oculata Harger, *S*, 252 fms.

a'. Eyes not contiguous. Flagellum of second pair of antennæ with fourteen to sixteen joints.

b. Propodus of prehensile legs with two to four spines.

c. First thoracic segment with antero-lateral angles produced horn-like at sides of head. Frontal margin of head produced. . . *Rocinela cornuta* Richardson, *A*, 625 fms.

c'. First thoracic segment normal. Frontal margin of head not produced.

d. Spots present on both sides of the fourth thoracic segment. *Rocinela maculata* Schiœdte and Meinert, *N*

d'. Spots wanting on fourth thoracic segment.

e. Spots present on fourth and fifth abdominal segment and base of terminal segment.

Rocinela belliceps (Stimpson), *APD*, surface to 138 fms. (See Fig. 6, p. 221.)

e'. Spots wanting on fourth and fifth abdominal segments and base of terminal segment.

Rocinela americana Schiœdte and Meinert, *NM*, 85–157 fms.

b'. Propodus of prehensile legs with five to six spines.

Rocinela laticauda Hansen, *APD*, 82–660 fms.

Genus Syscenus Harger. . . *Syscenus infelix* Harger, *M*, 231–435 fms.

Family IX. Cymothoidæ.

a. Head not at all immersed or set in the first thoracic segment.

b. Uropoda and terminal segment ciliated. Eyes large, conspicuous.
Ægathoa Dana

b'. Uropoda and terminal segment not ciliated. Eyes small.

c. Posterior angles of first thoracic segment prominent or produced, very often acute; posterior angles of the following segments increasing gradually in length, the first of these very often scarcely prominent, the posterior ones very often produced, abruptly longer than the first. Epimera of the first segments extending beyond the posterior angles of the segment; posterior ones produced, acute. Nerocila Leach

c'. Posterior angles of first six thoracic segments scarcely or not at all prominent; those of the seventh segment produced. Epimera of first segments very often almost or quite reaching, or not reaching by a short distance the posterior angle of the segment.

d. Body compact. Head not constricted. Uropoda very often more or less longer than terminal segment. Legs gradually increasing in length. Anilocra Leach

d'. Body relaxed. Head constricted at the base. Uropoda much shorter than terminal segment. Legs gradually much longer successively; seventh pair abruptly very much so. . . . . Olencira Leach

a'. Head more or less immersed or set in the first thoracic segment.

b. First pair of antennæ contiguous at the base.

c. Epimera of the first pair with a carina produced in the form of a spoon. Ungulæ very long, unequal in length; those of the third pair longest, abruptly longer than second pair. Terminal segment transverse. . . . Ceratothoa Dana

c'. Epimera of the first pair not produced. Ungulæ mostly very short, very rarely long, equal in length. Terminal segment subtriangular, semicircular, often bilobed. Meinertia Stebbing

b'. First pair of antennæ manifestly distant at the base.

c. Abdomen manifestly separated from the thorax, abruptly narrower than thorax. . . . . Cymothoa Fabricius

c'. Abdomen contiguous with thorax, not narrower than thorax. Livoneca Leach

Genus Ægathoa Dana.

a. Surface of head smooth, evenly convex. Second pair of antennæ ten-jointed. First thoracic segment longer than any of the succeeding segments, which are of equal length.
Ægathoa loliginea Harger, *M*

a'. Surface of head with central portion sharply raised above the lateral portion, which is deeply excavate just in front of the eyes. Second pair of antennæ eight-jointed. First three thoracic segments subequal; last four subequal, and somewhat shorter than first three.
Ægathoa medialis Richardson, *M*, 3–25 fms.

Genus Nerocila Leach.

a. Terminal segment regularly rounded. Head subtruncate in front. Eyes distinct, black. . . . . . . *Nerocila munda* Harger, *N*

a'. Terminal segment cordate, acuminate. Head rounded in front. Eyes indistinct, obscurely defined.

b. Uropoda scarcely longer than the apex of the terminal segment.
Nerocila acuminata Schiœdte and Meinert, *GSM*

b'. Uropoda much longer than the apex of the terminal segment.
Nerocila californica Schiœdte and Meinert. *D*

Genus Anilocra Leach.

a. Terminal abdominal segment regularly rounded. All the epimera extend fully to the posterior angles of their corresponding segments. Branches of uropoda longer than terminal segment.
Anilocra occidentalis Richardson, *D*, 19 fms. (See Fig. 7, p. 221.)

a'. Terminal abdominal segment subcordate. Two first epimera reach the posterior angles of the segments; last four do not reach the angles

FIG. 6. — *Rocinela belliceps.*

FIG. 7. — *Anilocra occidentalis.*

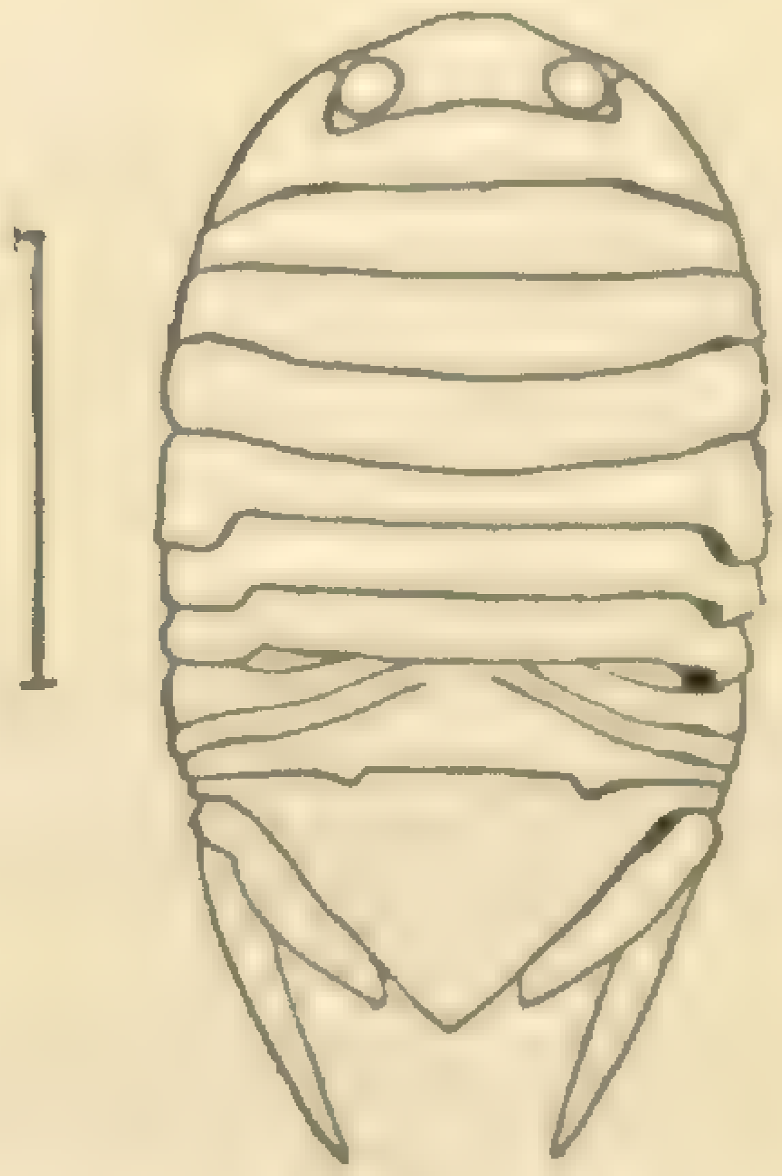

FIG. 8. — *Tecticeps alascensis.*

of the segments. Branches of the uropoda much shorter than terminal segment. . . . . *Anilocra laticauda* Milne Edwards, *MS*

Genus Olencira Leach. . . . . *Olencira prægustator* (Latrobe), *MSG*

Genus Ceratothoa Dana. . . . . . . *Ceratothoa linearis* Dana, *M*

Genus Meinertia Stebbing. *Meinertia transversa* Richardson, *G*, 347 fms.

Genus Cymothoa Fabricius.

a. Terminal segment lanceolate. . . . *Cymothoa lanceolata* Say, *M*

a′. Terminal segment transverse; posterior margin widely sinuated or bilobed.

b. Anterior angles of the first thoracic segment short, acute; sides of the segment a little constricted. Inner branch of the uropoda much shorter than outer branch.

Cymothoa excisa Perty, *MSG*

b′. Anterior angles of the first thoracic segment very large, equaling or surpassing the front of the head, rounded. Sides of the segment flexuous. Inner branch of the uropoda manifestly longer than outer branch. . . *Cymothoa œstrum* (Linn). *M*

Genus Livoneca Leach.

a. Abdomen immersed in thorax, the sides of the first segment being almost entirely covered by the seventh thoracic segment.

b. Head narrowly rounded in front.

Livoneca californica Schiœdte and Meinert, *PD*

b′. Head broad, roundly truncate in front.

Livoneca vulgaris Stimpson, *D*

a′. Abdomen not immersed in thorax, the sides of the first segment free.

b. Uropoda much longer than caudal segment: inner branch narrow, obtuse, much shorter than outer branch. Epimera of last two thoracic segments not longer than segments.

Livoneca redmanni Leach, *SG*

b'. Uropoda hardly surpassing the caudal segment; both branches equal in length. Epimera of last two segments of thorax surpassing the segments. Head narrowly rounded in front. . . *Livoneca ovalis* (Say), *NMSG*

FAMILY X. LIMNORIIDÆ.

Genus Limnoria Leach. . . . *Limnoria lignorum* (Rathke), *ANMS*

FAMILY XI. SPHÆROMIDÆ.

a. Outer branch of the uropoda small, almost rudimentary.
Cassidena Milne Edwards

a'. Outer branch of the uropoda not rudimentary.

b. Both external and internal branches of the uropoda projecting and exposed; outer branch capable of folding under inner.

c. Terminal segment of the abdomen entire.

d. Margins of the head not produced. Antennæ conspicuous. Legs normal. Mandibles with a five-jointed palp. . . . . Sphæroma Latreille

d'. Anterior and lateral margins of the head produced, concealing the antennæ. Propodus of first and second pairs of legs dilated, with reflexed dactylus. Mandibles with a three-jointed palp. . Tecticeps Richardson

c'. Terminal segment of the abdomen excavated at its extremity.
Dynamene Leach

b'. Only the external branch of the uropoda projecting and exposed; outer branch incapable of folding under inner.

c. All the thoracic segments of equal length. Penultimate abdominal segment in male generally produced in spine. Terminal segment excavated with or without median lobe.
Cilicæa Leach

c'. Sixth segment of the thorax much enlarged, and produced at the center far backwards, covering the shorter seventh segment for the most part. Terminal segment excavate.
Næsa Leach

Genus Cassidena Milne Edwards. . *Cassidena lunifrons* Richardson, *M*

Genus Sphæroma Latreille.

a. Body widening gradually from head backwards. Thorax transversely ridged and provided with three longitudinal rows of small tubercles. Branches of the uropoda very large, expanded.
Sphæroma amplicauda Stimpson, *APD*, surface

a'. Body not increasing in width. Surface of thorax smooth. Branches of the uropoda not expanded.

b. Extremity of terminal abdominal segment produced in a rhomboid process. . . . . *Sphæroma rhomburum* Richardson, *D*

b′. Extremity of terminal abdominal segment not produced.

c. Surface of abdomen tubercular.

d. Uropoda not reaching apex of terminal segment; outer branch the shorter and not denticulate. Terminal segment with eight tubercles.

Sphæroma octoncum Richardson, *D*

d′. Uropoda surpassing the apex of the terminal segment; outer branch the longer and provided with four teeth on external margin. Terminal segment with four tubercles.

Sphæroma destructor Richardson, Florida fresh-water

c′. Surface of abdomen smooth.

d. Outer branch of the uropoda denticulate on its external margin.

Sphæroma quadridentatum Say, *MS*, surface to ½ fm.

d′. Outer branch of the uropoda not denticulate.

e. Outer branch of the uropoda half as long as the inner branch, and half as wide.

Sphæroma thermophilum Richardson, New Mexico, fresh-water

e′. Outer branch of the uropoda not much shorter than inner branch, and of equal width.

Sphæroma oregonensis Dana, *APD*, surface to 12 fms.

Genus Tecticeps Richardson.

a. Terminal segment of abdomen pointed. Outer branch of uropoda much longer than inner branch. First pair of antennæ reach the posterior angle of the first thoracic segment. Second pair reach the middle of the second thoracic segment. Sixth and seventh pair of legs show a marked disproportion in the length of the propodus.

Tecticeps alascensis Richardson, *A*, 9–106 fms. (See Fig. 8, p. 221.)

a′. Terminal segment of abdomen widely rounded. Outer branch of uropoda not longer than inner branch. First pair of antennæ reach the posterior angle of the third thoracic segment. Second pair of antennæ reach the middle of the fourth thoracic segment. Sixth and seventh pairs of legs show only a gradual increase in length.

Tecticeps convexus Richardson, *D*, 5 fms.

Genus Dynamene Leach.

a. Frontal margin of head produced in a quadrangular process; first two joints of the first pair of antennæ dilated.

Dynamene dilalata Richardson, *D*, surface

a′. Frontal margin of head not produced; joints of first pair of antennæ not dilated.

b. Abdomen tuberculated. Neither branch of the uropoda reaching the extremity of the abdomen.

Dynamene tuberculosa Richardson, *AD*, surface

b′. Abdomen not tuberculated. Inner branch of the uropoda reaching the extremity of the abdomen.

c. Ultimate segment of the abdomen ridged. Branches of uropoda of equal length. Sinus at extremity of abdomen funnel-shaped.

Dynamene benedicti Richardson, *D*, surface

c′. Ultimate segment of abdomen smooth. Outer branch of uropoda but little more than half as long as inner branch. Sinus at extremity of abdomen small.

Dynamene glabra Richardson, *D*, surface

Genus Cilicæa Leach.

a. Terminal segment with three sinuses, one above another in a longitudinal series, the two upper openings heart-shaped. Outer branch of the uropoda armed with four spines.

Cilicæa cordata Richardson, *A*, surface

a′. Terminal segment with one sinus. Outer branch of the uropoda unarmed.

b. Sinus without teeth. *Cilicæa carinata* Richardson, *S*, 440 fms.

b′. Sinus with teeth.

c. Sinus with four teeth. Median tubercle at base of terminal segment single. . . *Cilicæa caudata* (Say), *M*, surface

c′. Sinus with six teeth. Median tubercle at base of terminal segment double.

Cilicæa caudata gilliana Richardson, *D*

Genus Næsa Leach. . . . . *Næsa* (?) *depressa* Say, *M*, surface

Næsa (?) *ovalis* Say, *S*, surface

FAMILY XII. SEROLIDÆ.

Genus Serolis Leach.

Serolis carinata Lockington, *D*, 3 fms. (See Fig. 9, p. 225.)

III. VALVIFERA.

a. Body more or less broad, depressed. Legs usually nearly alike, but first three pairs sometimes with propodus dilated and dactylus reflexed.

Family XIII. Idoteidæ

a′. Body narrow, scarcely depressed. Four anterior pairs of legs unlike three posterior pairs, and not ambulatory, nor strictly prehensile, directed forward, slender, ciliated, with terminal joint minute ; last three pairs stouter, ambulatory, with terminal joint bifid.

Family XIV. Arcturidæ

FAMILY XIII. IDOTEIDÆ.

a. Sides of head emarginate or cleft and laterally produced beyond the eyes, which are situated upon its dorsal surface. Three anterior

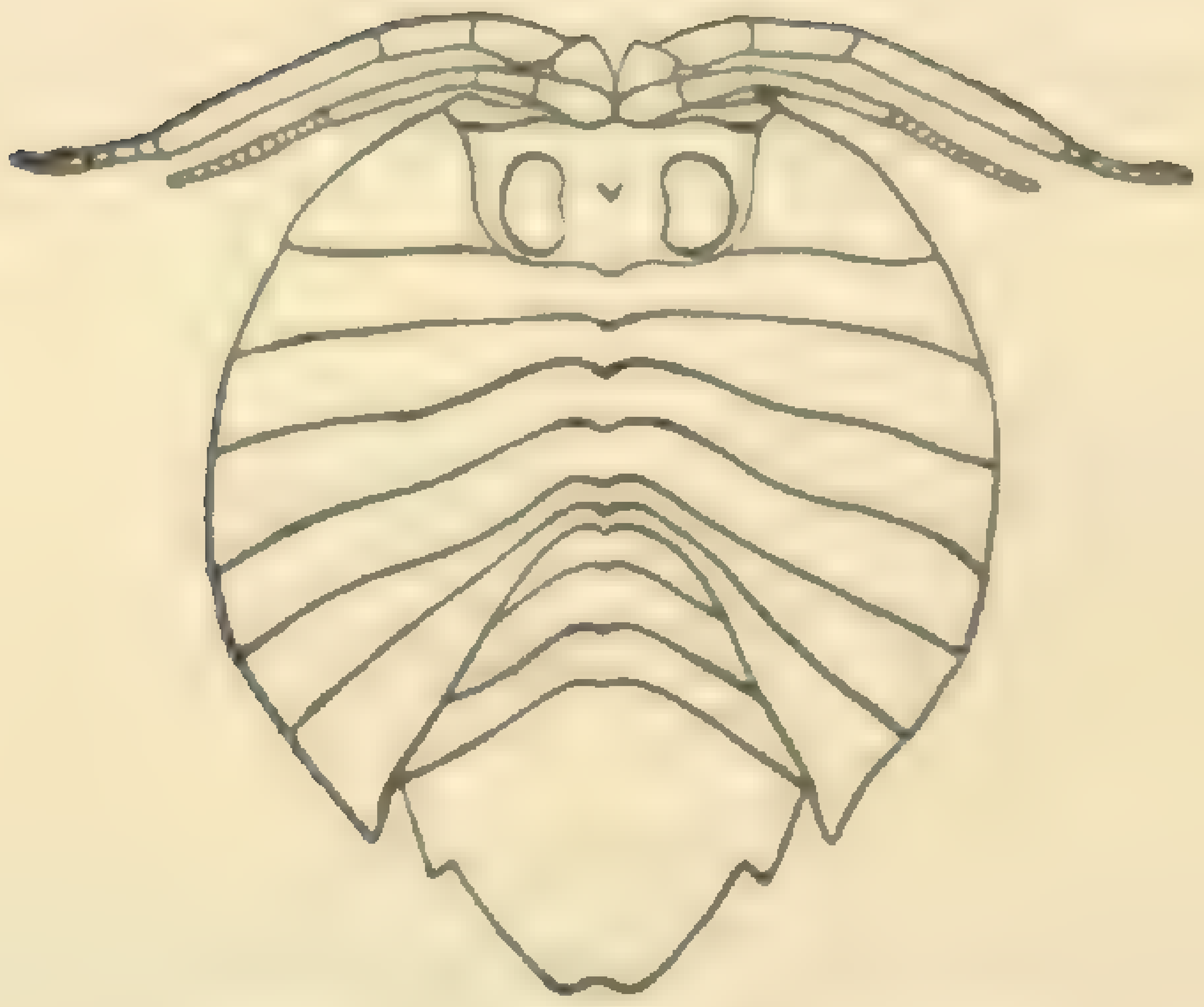

FIG. 9. — *Serolis carinata.*

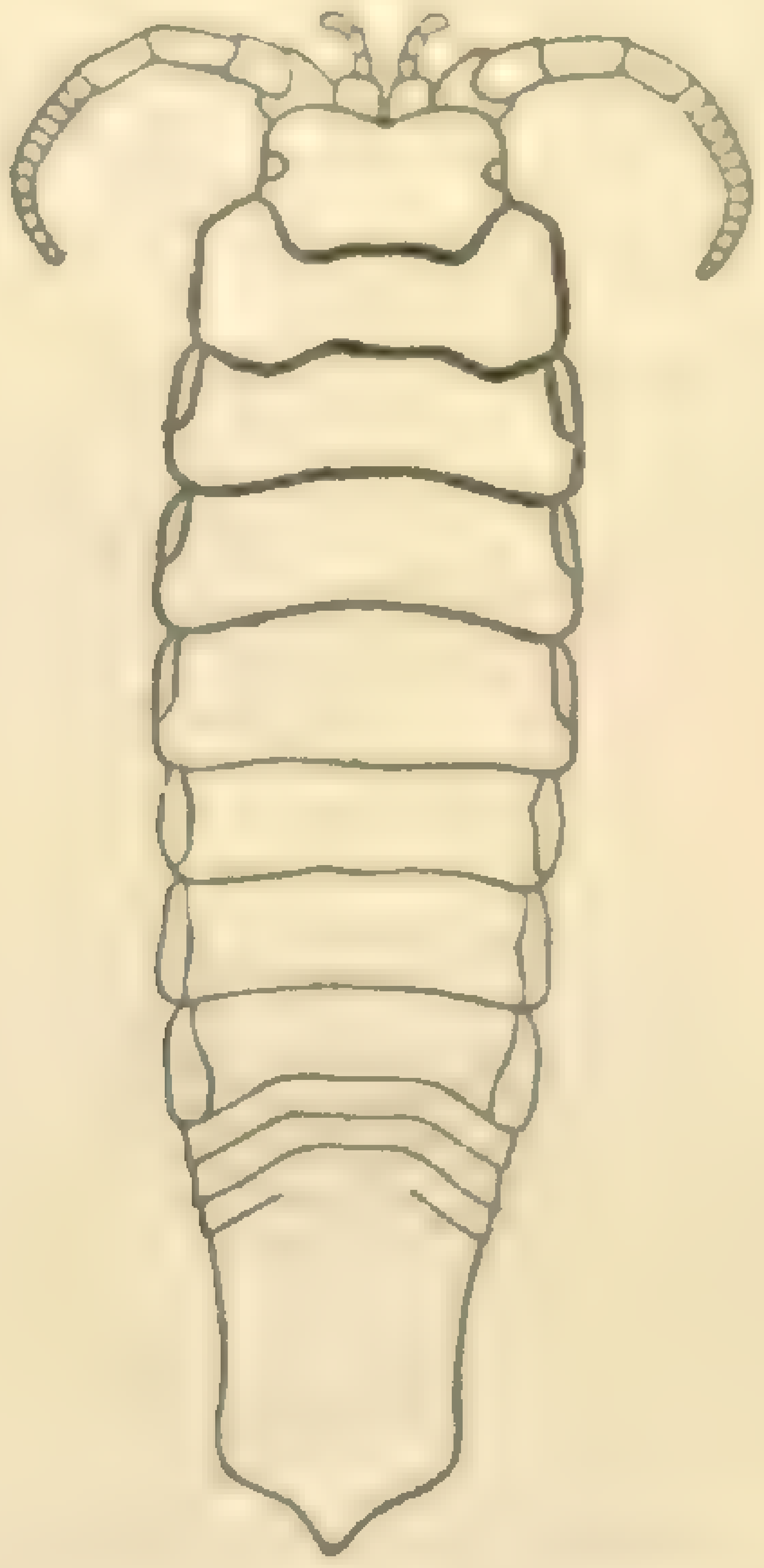

FIG. 10. — *Idotea ochotensis.*

pairs of legs, with penultimate joint or propodus dilated, and forming, with reflexible dactylus, a prehensile hand. All the epimera distinct. Chiridotea Harger

a'. Sides of head entire and not laterally produced. Eyes lateral. Legs all ambulatory; three anterior pairs with penultimate joint not or not much dilated.

b. Flagellum of second pair of antennæ well developed and multi-articulate.

c. Palpus of maxillipeds four-jointed. Epimera of all the segments well developed and evident in a dorsal view. Abdomen (including the terminal segment) consisting of three segments with lateral sutures, indicative of another partly coalescent segment. . . . . . . Idotea Fabricius

c'. Palpus of maxillipeds not four-jointed. Abdomen consisting of one segment, uniarticulate.

d. Palpus of maxillipeds three-jointed. All the epimera coalesced and perfectly united with the segments. Synidotea Harger

d'. Palpus of maxillipeds two-jointed. Epimera of second, third, and fourth segments coalesced and perfectly united with the segments; those of the fifth, sixth, and seventh segments distinct and well developed. Colidotea Richardson

b'. Flagellum of second pair of antennæ not multi-articulate.

c. Flagellum of second pair of antennæ rudimentary. Second pair of antennæ a little longer than first pair. Edotea Guérin-Ménéville

c'. Flagellum of second pair of antennæ usually obsolete. Second pair of antennæ much longer than first pair.

d. Legs subequal. Antennæ geniculate. Palp of maxillipeds four-jointed. Body angulate.
Erichsonella Benedict

d'. Third and fourth pairs of legs usually markedly shorter. Fifth, sixth, and seventh pairs gradually increasing in length. Antennæ not geniculate. Palp of maxillipeds two-jointed. Body slender, linear, smooth.
Cleantis Dana

Genus Chiridotea Harger.

a. Species large, elongate-ovate. Outer branch of uropoda (or opercular valves) minute.

b. Joints of the peduncle of the antennæ not dilated; flagellum eight to fourteen-jointed. Antero-lateral cervical lobes prominent. . *Chiridotea entomon* (Linn.), *AP*, surface to 15 fms.

b'. Joints of the peduncle of the antennæ greatly dilated; flagellum seven to eight-jointed. Antero-cervical lobes prominent.
Chiridotea sabinii (Krøyer), *AN*, surface to 15 fms.

a'. Species small, orbiculate-ovate. Outer branch of uropoda at least half as long as inner.

b. Antennæ little longer than antennulæ; flagellum seven-jointed. Eyes inconspicuous. Antennulæ longer than the peduncle of the antennæ. . . . *Chiridotea cœcas* (Say), *NMS*, surface

b'. Antennæ twice as long as antennulæ; flagellum twelve-jointed. Eyes usually distinct. Antennulæ do not surpass the peduncle of the antennæ.
Chiridotea tuftsii (Stimpson), *NM*, surface to 25 fms.

Genus Idotea Fabricius.

a. Terminal segment emarginate at its extremity.
Idotea resecata Stimpson, *AD*, surface

a'. Terminal segment not emarginate at its extremity.

b. Body slender, linear, filiform.

c. Terminal segment truncate at apex.
Idotea gracillima Dana, *D*

c'. Terminal segment not truncate at its extremity.

d. Post-lateral angles of terminal segment prominent and separated by a tooth from subtriangular middle portion, which bears a small tooth at the middle.
Idotea urotoma Stimpson, *P*

d'. Post-lateral angles not separated by a tooth from middle portion.
Idotea rectilineata Lockington, *D*, 30–40 fms.

b'. Body oblong-ovate.

c. Terminal segment truncate at its extremity.
Idotea metallica Bosc, *NM*, surface 91 fms.

c'. Terminal segment not truncate.

d. Terminal segment regularly and broadly rounded at its extremity, with small median tooth.
Idotea wosnesenskii Brandt, *APD*, surface to 9 fms.

d′. Terminal segment acute or distinctly toothed at its extremity.

e. With prominent post-lateral angles or teeth on either side of median tooth.

f. With acute lateral teeth.
Idotea marina (Linn.), *NM*, surface to 119 fms.

f′. With rounded lateral lobes.

g. Epimera of second, third, and fourth segments short, not reaching the post-lateral angles of their respective segments.
Idotea ochotensis Brandt, *A*, surface to 18 fms. (See Fig. 10, p. 225.)

g′. Epimera of all the segments reaching the post-lateral angles of their respective segments.

h. Sides of thorax arcuate.
Idotea stenops Benedict, *D*

h′. Sides of thorax more nearly parallel.
Idotea whitei Stimpson, *PD*

e′. With sides sloping regularly to produced extremity.
Idotea phosphorea Harger, *N*, surface to 18 fms.

Genus Synidotea Harger.

a. Terminal abdominal segment emarginate or notched at its extremity.

b. Two spines or tubercles overhanging the frontal notch.

c. Spines united near the base.
Synidotea pallida Benedict, *A*, 695 fms.

c′. Spines free at base.
Synidotea erosa Benedict, *A*, 483 fms.

b′. No spines or tubercles overhanging the frontal notch.

c. With a low ridge arising between the eyes and interrupted on the median line.

d. Outlines of abdomen subparallel.
Synidotea nebulosa Benedict, *A*, 9–32 fms.

d′. Outlines of abdomen strongly arcuate.
Synidotea angulata Benedict, *AP*, 31–38 fms.

c′. Without a ridge between the eyes.

d. Outline of abdomen subtriangular.

e. Front not excavated.
Synidotea consolidata (Stimpson), *P*

e′. Front excavated.

f. Outlines of thorax subparallel.
Synidotea marmorata (Packard), *N*, 36–129 fms.

f′. Outlines of thorax strongly arcuate.
Synidotea bicuspida (Owen), *AN*, 5–13½ fms.
d′. Outlines of abdomen rounded.
Synidotea laticauda Benedict, *A*, surface to 56 fms.
a′. Terminal abdominal segment pointed at its extremity.
b. Undulations of body not tubercular or spiny.
c. Tubercle in front of eyes not margined.
Synidotea nodulosa (Krøyer), *AN*, 16–119 fms.
c′. Tubercle on the frontal margin and forming a part of it.
Synidotea lævis Benedict, *A*, 29–36 fms.
b′. Undulations of the body tubercular and spiny.
c. Four spines on the front of the head; body spinous.
Synidotea muricata (Harford), *A*, 25 fms.
c′. A wedge-shaped tubercle behind the frontal notch; body tubercular. . . . *Synidotea picta* Benedict, *A*, 9 fms.

Genus Colidotea Richardson . . . . *Colidotea rostrata* (Benedict), *P*

Genus Edotea Guérin-Méneville.

a. Anterior angles of head produced into horn-like projections. Lateral angles of thoracic segments produced into horn-like projections. Four tubercles situated on dorsal surface of head.
Edotea acuta Richardson, *N*, 105 fms.
a′. Anterior angles of head not produced into horn-like projections. Lateral angles of thoracic segments not produced into horn-like projections. Two tubercles situated on dorsal surface of head.
b. Lateral margins of thorax nearly even. Anterior angles of head not salient. Lateral margins of terminal segment scarcely indented.
Edotea triloba (Say), *NM*, surface to ½ fm.
b′. Lateral margins of thorax angulated and salient. Anterior angles of head salient. Lateral margins of terminal segment indented; terminal segment rather elongated.
Edotea montosa (Stimpson), *NM*, 2–40 fms.

Genus Erichsonella Benedict.

a. Surface of body smooth throughout. Outline of body regular. Antennulæ short. Terminal segment of body with but slight traces of a lateral tooth near its base on either side.
Erichsonella attenuata (Harger), *M*
a′. Surface of body tuberculated. Outline of body serrate. Antennulæ long. Terminal segment with a prominent lateral tooth near its base on either side. Large bifid tubercle on center of head. Median longitudinal row of tubercles on each thoracic segment.
Erichsonella filiformis (Say), *M*, 4½ to 7 fms.

Genus Cleantis Dana.

a. Flagellum consolidated and forming a single piece. Abdomen composed of four segments. Terminal abdominal segment with rounded

extremity; terminal portion of segment obliquely truncated, the oblique portion being surrounded by a raised margin.

Cleantis planicauda Benedict, *G*

a'. Flagellum composed of three joints. Abdomen composed of three segments. Terminal abdominal segment with acute post-lateral teeth on either side of rounded posterior portion. Surface of segment smooth throughout. . . . . *Cleantis heathii* Richardson, *D*

Family XIV. Arcturidæ.

a. Fourth segment of thorax not greatly longer than others. Marsupium of female composed of four pairs of plates. . . Arcturus Latreille

a'. Fourth segment of thorax much longer than any of the others. Marsupium of female consisting of two plates affixed to this segment.

Astacilla Fleming

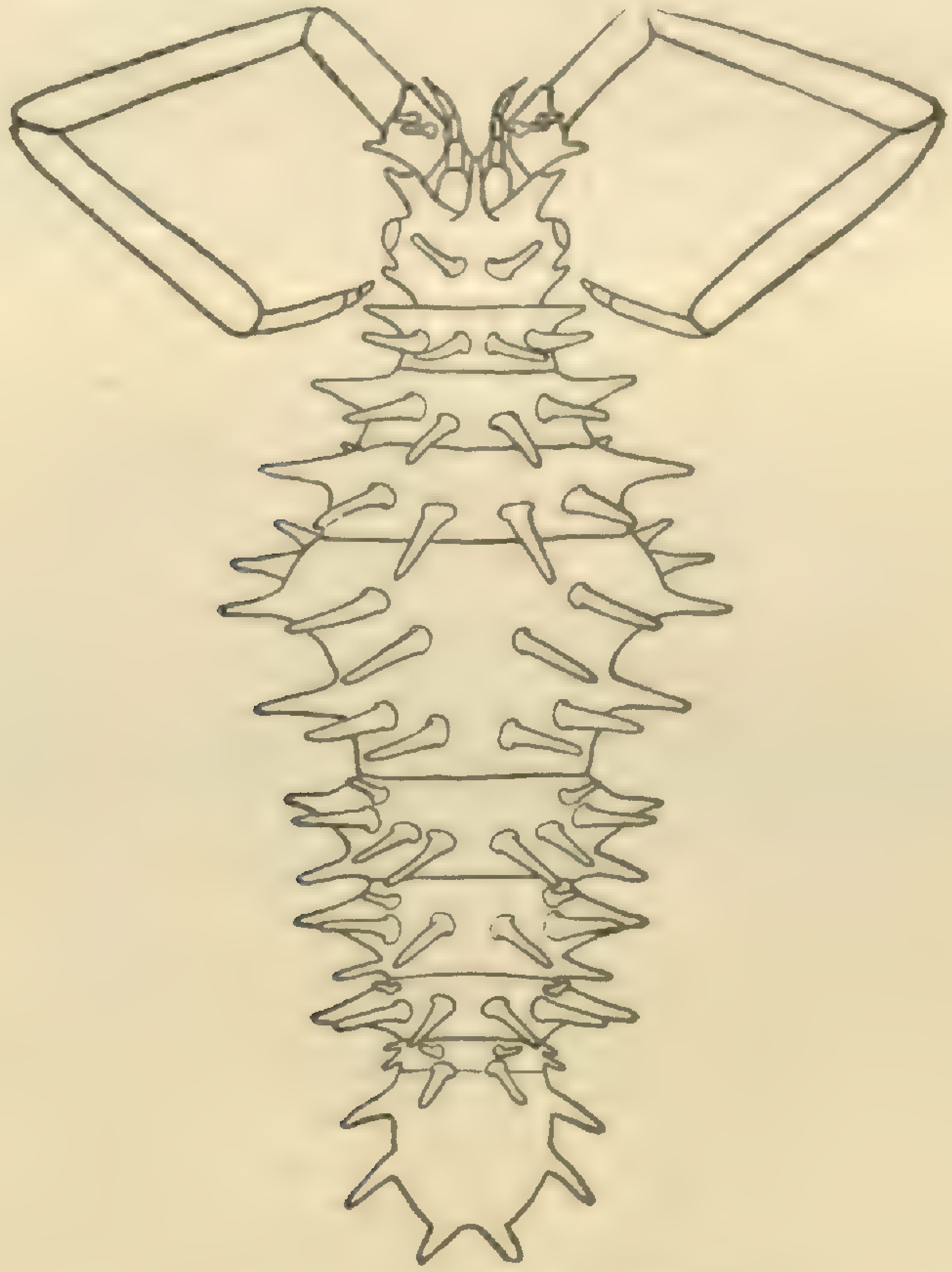

Fig. 11. — *Arcturus intermedius.*

Genus Arcturus Latreille.

a. End of terminal abdominal segment notched, as seen from above.

b. Body smooth and free from spines.

Arcturus beringanus Benedict, *A*. 29–36 fms.

b'. Body spiny.

c. Head and six segments of thorax, each with a pair of spines on the dorsum. Second and third articles of the antennæ without spines. *Arcturus longispinis* Benedict, *A*. 55 fms.

c'. Head and segments of thorax with not less than two pairs of spines to the segment.

d. Head with one large median spine on the anterior part of the head in front of the eyes.

Arcturus intermedius Richardson, *A*, 10 fms. (See Fig. 11, p. 229.)

d'. Head with three spines on anterior part of head in front of eyes.

Arcturus murdochi Benedict, *A*, 13½ fms.

a'. End of terminal abdominal segment without notch.

b. Thorax without spines above the epimera.

Arcturus glaber Benedict, *A*, 55 fms.

b'. Thorax with spines above the epimera.

c. Terminal segment of abdomen armed with a long median terminal spine, projecting beyond the end of the segment.

Arcturus floridanus Richardson, *S*

c'. Terminal segment of abdomen not armed with long median terminal spine.

d. Four anterior segments of thorax with spines or tubercles. Middle surface of abdomen with prominent spiny projections. With conical lateral projections. Epimera pointed.

Arcturus baffini (Sabine), *N*, 110–150 fms.

d'. Four anterior segments of thorax without spines or tubercles. Middle surface of abdomen without any indication of prominent spiny projections. Without conical lateral projections. Epimera less pointed.

Arcturus feildeni Miers, *N*, 30 fms.

Genus Astacilla Fleming.

a. With eyes. Head excavate in front without rostriform point. Fourth thoracic segment subcylindrical. Terminal abdominal segment with a prominent, subacute tooth on each side, above the middle, directed outward and backward; extremity obtuse.

Astacilla granulata (G. O. Sars), *N*, 7–250 fms.

a'. Without eyes. Head with a rostriform point in front between the antennulæ. Fourth thoracic segment wider at the anterior end, and tapering to the posterior end. Terminal abdominal segment with a pair of teeth on each side; extremity acute.

Astacilla cæca Benedict, *N*, 1825 fms.

REVIEWS OF RECENT LITERATURE.

ANTHROPOLOGY.

Payne's New World. — The second volume of this work, composed by an Oxfordian scholar, was published last year, and for its great intrinsic value deserves an extended notice; indeed there are but few historic works treating about this western continent that are written in a more careful and painstaking spirit. The full title is: *Edward John Payne, History of the New World, called America*, Vol. II. Oxford, at the Clarendon Press, 1899; octavo, pp. 27, 548. The volume begins with a sociological discussion on the pre-Columbian condition of the American tribes, their warrior and peasant classes, and the origin of the industrial class. Woman was the primitive laborer; she became enslaved by capture or by purchase, and the marriage question in the earliest epochs was nothing but a part of the problem of the food quest. The organization of the laboring class and the distribution of slaves and of land form another sociological chapter well worth studying. Then follows the discussion on the origin of the tribe, the horde, the family, the clan, the great house, together with the tribal migrations and the motives impelling peoples to migrate. The headings of subsequent sections of the work are as follows: Antiquity of Man in America; Ethnological Unity of the Aborigines; Origin and Process of Language; Material Aspect of Speech; Adaptation of Elementary Movements to Articulation; Mechanics of Language — Repetition; Original Aspects of Personality; Dynamics of the Holophrase; Differentiation of the Noun and Verb; Dispersonalization; Distinction of Number in Objects; Primitive Applications of Arithmetic; Calendars or Time-reckoning; Mexican Calendar; Spread of Man over the New World; History of the Nahuatlacâ (Mexicans); First Nahuatlacan Immigrants; Aculhuan Pueblos of the Plateau; The Valley of Mexico; The Aztecs; Peruvian Advancement.

To give our readers an idea how interestingly the material is handled by Payne, we transcribe what he says about agricultural communities, exclusively composed of women (pp. 10, 11), as have been discovered in many parts of the inhabited earth. "Such communities were formed, it would seem, by the same process of spon-

taneous emigration, derived their continuity from periodical visits, usually once a year and lasting for a month in the spring, by males from other tribes. Columbus, while coasting Haiti (1493), heard of such a community from an Indian who visited him on board the *Niña*. The account was precise; the women of 'Matinino' admitted annually, as temporary members of their tribe, a certain number of male visitors, who carried back with them, on departing, the male children born in each interval, the women retaining the girls to replenish their own society (Las Casas, *Historia*, Vol. I, p. 434). Later accounts afford a body of evidence strongly tending to prove the existence of such societies in the valley of the mighty stream on which these communities have indelibly stamped the name of River of Amazona. He who summarily rejects these accounts knows little of the realities of the transition from savagery to barbarism. Women, as the Spaniards often found to their cost, can use the bow and arrow not less effectively than men. In possession of this deadly weapon, as well as of the materials of subsistence, they might easily form independent communities, and maintain them by the means adopted by the South American Amazons for an indefinite period. When women, says Southey, have been accustomed to accompany their husbands to battle, there is nothing that can be thought improbable in their establishing themselves as an independent race and thus securing that freedom for their daughters which they had obtained for themselves."

It is important to notice that one-half at least of the volume treats of linguistics. The languages of the American natives are analyzed and, as to their mental capacities, compared with those of the Old World.

Some are possessed of highly polysynthetic features, whereas others have scarcely attained the lower degrees of agglutination. A few of their number may be called analytic, like those of the Maya family, but the majority are synthetic.

A. S. GATSCHET.

ZOOLOGY.

Koelliker's Reminiscences. — The reminiscences of a long life of interesting and worthy activity form the latest volume from Professor Koelliker.[1] The book contains a little over four hundred pages, of

[1] Koelliker, A. *Erinnerungen aus meinem Leben.* Leipzig, W. Engelmann. 1899. vi + 399 pp., 8 plates, and 10 text-figures.

which the first fifty are devoted to an autobiography, followed by something over a hundred on the author's scientific and other travels, and concluded by a résumé of his scientific work. There are numerous illustrations, including several portraits of the author.

Degeneration of Duodenal Glands in the Cat. — Stöhr[1] has recently shown that in fully grown cats single duodenal glands, or even parts of such glands, may completely degenerate; the degeneration begins with a thickening of the connective tissue surrounding the glands, followed by the death of the gland cells and their absorption by leucocytes.

P.

Greeley on Tide-Pool Fishes of California. — In the *Bulletin of the U. S. Fish Commission* for 1899 is a report by Arthur White Greeley, teacher of biology in the State Normal School of San Diego, on the fishes collected by him at the tide pools of California.

The small marine sculpins originally forming Girard's genus Oligocottus are here divided into seven genera: Blennicottus Gill, Oxycottus Jordan, Rusciculus Greeley, Dialarchus Greeley, Oligocottus, Clinocottus Gill and Eximia Greeley; and four new species, *Blennicottus recalvus*, *Rusciculus rimensis*, *Dialarchus snyderi*, and *Eximia rubellio*, are described and well figured. Greeley shows that the original types of *Blennicottus globiceps* and *Oligocottus maculosus* belonged to the northern forms, the species called *Blennicottus bryosus* and *Oligocottus borealis*, by Jordan and Evermann. This fact necessitates the new names of *Blennicottus recalvus* and *Dialarchus snyderi* for the species common to the southward of Monterey. The figure of *D. snyderi* is apparently taken from a female and fails to show the separation of the enlarged first anal ray on which the genus is based.

Mr. Greeley concludes from his study of intergrading forms that no real difference exists between the northern species of *Gibbonsia* (*evides*) and the southern *Gibbonsia elegans*.

The pools of the rocky coasts of California, a region with high tides and a profuse growth of algæ, are especially rich in fish life. Those from Pescadero to Monterey have been very fully studied by Mr. Greeley, more carefully than by any one else. On the coast of Mexico the poisonous milky juice of the tree called Hava (contain-

[1] Stöhr, P. Ueber Rückbildung von Duodenaldrüsen, *Festschrift der phys.-med. Gesellschaft zu Würzburg*, pp. 209–214, 1 Taf., 1899.

ing strychnine) has been found very useful in killing the fishes of these pools, often not to be captured in any other way. Mr. Greeley found a good substitute for this poison in the commercial chloride of lime.

D. S. J.

Development of Brain Structures in Amia. — A. C. Eyclesheimer and B. M. Davis give in the *Journal of Comparative Neurology* a valuable study of "The Early Development of the Epiphysis and Paraphysis in Amia." The paper indicates that much is still to be known as to the origin of epiphysial outgrowths from brain structures.

D. S. J.

Scapanorhynchus and Mitsukurina. — In the *Annals and Magazine of Natural History*, Mr. A. S. Woodward, of the British Museum, has a note on *Mitsukurina owstoni* Jordan, an extraordinary lamnoid shark with a long flat blade on its snout, lately described from the deep waters of Japan.

Mr. Woodward shows that Mitsukurina is very closely related to the Cretaceous genus Scapanorhynchus, of which species are known from Mount Lebanon and from the chalk of England.

Mitsukurina and Scapanorhynchus agree in the elongate, blade-like snout, which is, however, longest in Scapanorhynchus. The skeleton, dentition, and gill openings seem to be similar in the two genera, and there appear to be no great differences in the fins. The dense shagreen is also similar in the two; the structure of the basal cartilages of the fins in Scapanorhynchus is unknown; nor is anything known of the claspers.

Mr. Woodward concludes that Mitsukurina is probably identical with his genus, Scapanorhynchus, this name being of prior date. On the other hand, it may be urged that this identity is not proved, and that the specific differences are considerable. There are great disadvantages in the identification of recent fishes with fossil genera which are more or less imperfectly known.

More complete knowledge of the extinct forms often shows that the recent species have undergone such differentiation as should constitute generic difference. I think it, therefore, better to retain for the recent shark the name Mitsukurina, although recognizing its close relationship to its Cretaceous homologue.

The family Mitsukurinidæ is supposed to differ from Carchariidæ (Odontaspididæ) in the presence of a Polyodon-like snout, and perhaps in the structure of its fins and claspers. The writer knows too

little of the fossil forms of this type to form a final opinion as to whether, in view of the relations of the fossil forms, the family Mitsukurinidæ can be maintained.

D. S. J.

The Lateral Line of the Toadfish. — Miss Cornelia M. Clapp, professor of zoölogy in Mount Holyoke College, presents as a doctor's thesis in the University of Chicago a careful study of "The Lateral Line System of Batrachus tau."

Dr. Clapp concludes that the lateral line represents an organ of special sense. "The ear seems like a connecting link between the system of lateral line organs from which it has probably originated and the most highly sensory structure in Vertebrata — the eye. Ayers has shown that the auditory organ is in reality a series of canal organs innervated by two distinct cranial nerves." It seems certain that a more thorough knowledge of the changes in these cutaneous sense organs found in fishes and in the embryonic stages of higher types is essential to the understanding of the nervous system itself as developed in higher forms.

It may be noticed that the proper name of our toadfish is *Opsanus tau*, not *Batrachus tau.* The name Batrachus was applied by Bloch and Schneider in 1801 to the scaly toadfishes of the tropics, which had still earlier received from Lacépède the name Batrachoides. The name is not, therefore, available for any other genus, and the second name in date, the first ever given to the type in question, must be chosen. This is Rafinesque's Opsanus.

D. S. J.

Greene on the Lateral Line of the California Toadfish. — In the *Journal of Morphology*, Dr. Charles Wilson Greene, of Stanford University, has an elaborate study of the complex lateral line of another species of toadfish, *Porichthys notatus*, of the California coast. This species has several lateral lines, each of the most complex character, far more specialized than in the common toadfish. The pores in the genus Porichthys are accompanied by round shining bodies resembling the luminous spots in certain deep-sea forms, as Sternoptyx and Myctophum. In Porichthys the shining bodies are not known to be self-luminous, and their origin is plainly in the lateral line. The other genera are not related to Porichthys, and in them the luminous spots are not outgrowths from the lateral canal system.

Dr. Greene makes no attempt to discuss the homology or significance of the lateral line. Too few forms have yet been studied to make such discussion conclusive. He gives a full account of the

anatomy of the shining bodies in Porichthys. He concludes that these are true phosphorescent organs.

Thus far no specimens have been found to be luminous in the aquarium, and light has not been developed through electric stimulation, or by excitement through ammonia.

D. S. J.

Absence of Retinal Pigment in the Dogfish. — In his study of the retina of the common dogfish (*Mustelus vulgaris*) Schaper[1] has made the noteworthy observation that the retinal pigment cells, which in most vertebrates are loaded with dark pigment granules, are in this animal absolutely devoid of such particles.

P.

Pupa-Grafting in Moths. — The method of grafting young animals, as devised by Born for tadpoles, has been applied by Crampton[2] to the pupæ of moths. An injured pupa at best regenerates sufficient integument to cover the wound. Parts of two longitudinally split pupæ joined in natural proportions failed to unite, but anterior and posterior portions cut at any level united. Compounds slightly smaller than normal or enlarged by the insertion of a ring failed to coalesce. Fragments grafted on whole pupæ formed exactly those portions they would have formed had they remained on the original pupa. Pupæ are easily united sidewise or endwise, but in these, as in all other cases, the union is that of the integument and superficial parts only. The results of these experiments on the colors of different species are especially interesting. When individuals of two species having different colors were united so that their hæmolymphs mingled, the outcome was almost always a double animal whose colors were normal. The same result was obtained from united males and females in species with differently colored sexes. The colors are probably produced, as a rule, through the action on the hæmolymph of a localized internal factor such as the "ferment" cytoplasm assumed by Mayer.

P.

Amitotic Followed by Mitotic Cell Division. — The observations of Gerassimoff, that cooling would convert the mitotic division of Spirogyra cells into amitotic, and of Pfeffer and Nathanson, that a

[1] Schaper, A. Die nervösen Elemente der Selachier-Retina in Methylenblaupräparaten, *Festschrift zum siebenziegsten Geburtstag von Carl von Kupffer*, 10 pp., 3 Taf. Jena, 1899.

[2] Crampton, H. E. An Experimental Study upon Lepidoptera, *Archiv für Entw.-mech.*, Bd. ix, pp. 293–318, Pls. XI–XIII, 1899.

temporary use of ether would call forth in the same plant a temporary amitotic division, led Häcker[1] to subject developing eggs to the action of ether to ascertain whether their mitotic division could be converted into a temporary amitotic one. The results of these experiments are that when the eggs of Cyclops are subjected to the action of five per cent ether for from two to three hours, they begin to divide by a process many steps of which have all the appearances of amitotic division, and that after being returned to fresh water they reassume normal mitotic division. Cells, then, after dividing by what to all appearances is amitosis, may return to mitosis. Till further study proves absolute identity the author prefers to call this induced amitosis *pseudoamitosis.* P.

A New Unattached Hydroid. — In a paper on Woods Holl Hydroids, L. Murbach[2] redescribes *Corynitis Agassizii* and its medusa Gemmaria, and gives an account of a very remarkable unattached hydroid. It is represented by a single unbranched polyp of the Tubularian type with two circles of tentacles. A primitive perisarc envelops the hydrocaulus, at the end of which polyp buds are given off. Sexual reproduction takes place, the gonophores being between the two circles of tentacles. The polyp moves slowly from place to place and may be caught floating in quiet water. The author names it *Hypolytus peregrinus* and forestalls the systematic reviser by the statement: "Should the name here proposed for this new genus be preoccupied, I propose instead Gonohypolytus." P.

Hydra Grafts. — The grafting of hydras has been studied by H. W. Rand.[3] Lateral grafts do not persist as permanent abnormalities, but either constrict and separate from the stock or are resorbed by it. If the graft is large or has tentacles, it, as a rule, eventually separates from the stock; if it is small and without differentiated parts it may be resorbed. All the pieces that were resorbed were much larger than the minimum piece capable of regenerating if not employed as a graft. Lateral grafts differ from buds in that they do not separate from the stock as readily as buds do

[1] Häcker, V. Mitosen im Gefolge amitosen-ähnlicher Vorgänge, *Anat. Anzeiger*, Bd. xvii, pp. 9–20, 1900.

[2] Murbach, L. Hydroids from Woods Holl, Mass., *Quart. Journ. Micr. Sci.*, vol. xlii, pp. 341–360, Pl. 34, 1899.

[3] Rand, H. W. The Regulation of Graft Abnormalities in Hydra, *Archiv für Entw.-mech.*, Bd. ix, pp. 161–214, Taf. V–VII, 1899.

from parents. The regulation of abnormalities in Hydra appears to be independent of external conditions, and seems to be rather an effect of certain qualities inherited by the organism. P.

Notes. — The third edition of Van Gehuchten's[1] well-known textbook on the nervous system of man has just been published. The work has been increased in bulk and now appears in two volumes of about six hundred pages each. The first volume contains a full account of the gross anatomy of the nervous system, the neurone, and the finer anatomy of the spinal cord; the second volume deals with the finer anatomy of the brain.

No. VII of Vol. III of the *American Journal of Physiology* contains the two following articles: "The Poisonous Character of a Pure NaCl Solution," by Jacques Loeb, and "Observations on the Degeneration and Regeneration of Motor and Sensory Nerve Endings in Voluntary Muscle," by G. C. Huber.

BOTANY.

Minnesota Plant Life.[2] — The broad scope of the botanical work that is being done in Minnesota by Professor MacMillan is evidenced by the present volume. *Minnesota Plant Life* is the third volume of the botanical series of the reports of the natural history survey of the state. Notwithstanding, the book is not only not at all technical in the accepted sense, but, in accordance with the avowed purpose of the author, it is presented in as untechnical and popular a form as possible. Every botanist is quite too familiar with the result of the usual popular presentation of any portion of the subject. Popular treatises on biological science, especially, have come to stand for everything that is loose in thought, inexact in treatment, and antique in doctrine. Matters have practically reached a point where no master in scientific thought will write a popular treatise, and where no mere dilettante is able to write a scientific one. Professor MacMillan's book is proof that it is possible to write popularly,

[1] Van Gehuchten, A. Anatomie du système nerveux de l'homme, tomes i, ii. Louvain, 1900.

[2] MacMillan, Conway, Professor of Botany in the University of Minnesota. St. Paul, *The Pioneer Press*, 1899. 8vo, xxv, 568 pp. Four plates and 240 illustrations.

i.e., untechnically, and at the same time in a genuinely scientific vein. While one may not agree at every point with the detail of the text, he is struck by the fact that there is here no loose statement and antiquated theory, while rare inexactitudes are to be explained by the difficulty of presenting in popular form, which is always quasi-didactic, matters upon which botanists themselves are not harmonious.

The tenor of the volume is indicated by the author's purpose to present the plant world as an assemblage of living things. This is accomplished by presenting the different taxonomic groups morphologically, by treating generally of structures and functions from an adaptational standpoint, and by pointing out the main biological facts in plant association. The first two chapters, which are in many respects the best, the most suggestive ones in the book, deal briefly but in a clear, elementary manner with distribution, zonation and migration. Considering its brevity, the question of zonation is especially well handled. An objection that might be brought against the treatment in certain places (pp. 5, 9, and elsewhere) is that it is quite too teleological. The allegorical method of statement is certainly the readiest, and, among scientists, it is perhaps as good as any. Taken in connection with the appalling literalness of beginners, it is unsafe, and invariably leads to confusion, if not to error, in the consideration of purpose and design.

Chapters III–XL, constituting much the larger part of the book, are concerned with a survey of the groups of plants from the slime moulds to the composites. The part dealing with the cryptogams is especially good, noticeably superior to the portion given over to the flowering plants. The latter is fluent and readable, but the structural standpoint is predominant to the exclusion of many matters of interest. The latter fact is probably to be explained by the need of keeping the size of the volume within reasonable limits. The author is certainly right in placing the consideration of structure before that of function and adaptation. Had it been possible, however, a modicum of the two would have increased the interest and the suggestiveness of this portion. The chapter upon the bacteria is a model of its kind. The freshness of the matter, taken with its concise thoroughness, will make it the most interesting and instructive part of the book, not only to those to whom the work is addressed, but to many botanists as well. In Chapter XX the author has not been so fortunate in his treatment of seeds and their production. No exception can be taken to the statement, but the exposition will doubtless produce confusion in the subject for those who come to it for the

first time. The same criticism holds elsewhere in the treatment of alternation of generations. Though both are confessedly stumbling-blocks for beginners, it seems certain that a development of these matters phylogenetically would have been more logical and more successful.

The consideration of adaptation to environment is comprehensive and replete with suggestions. Occasional inaccuracies creep in, and in a few instances doubtful or debatable explanations are presented as certain. The ecological factors considered are gravity, mechanical forces, heat, light, moisture, soil composition, and biological environment. Following this a chapter is given to the treatment of hydrophytes and one to xerophytes. Halophytes and mesophytes are also considered briefly. The treatment is good in the main, but in certain places it lacks coördination. This is doubtless due to lack of space, since the detail itself has apparently required pruning. The last two chapters deal with the intimate processes in the life of the individual and of the species. Protoplasm is treated of in a peculiarly striking and clear manner. Nutrition, growth, movement, protection likewise receive elementary treatment in simple logical fashion. The maintenance of the species, involving the phenomena and problems of propagation and reproduction, is clearly stated and is most suggestive.

Books, like people, are well dressed when the dress is not noticed. Until they attain this standard, however, it is a distinct pleasure to have to do with a book in so many ways faultless as the present one in the art of printer and engraver. When it is borne in mind that it belongs to the dubious class of "state-printed" books, it is at once seen how painstaking the author must have been to have produced a book of such uniform excellence of press-work and illustration.

It is novel and encouraging that a book of this sort should be published by the Board of Regents of a large university for the instruction of the people of the state. It is a distinct misfortune that the book is not on the market, as it should be found as a reference or reading book in all schools in which botany is taught.

FREDERIC E. CLEMENTS.

The Local Floras of New England. — In 1890 Dr. Britton published a list of state and local floras of the United States and British America, which has been of very great use to botanists working on the classification and distribution of our native plants. One hundred and six titles appear for the New England States. Miss

Mary A. Day, of the Gray Herbarium, has just distributed a pamphlet,[1] reprinted from Vol. I of *Rhodora*, in which 258 titles of books and papers referring to the flora of New England are cited, bringing the record down to the end of 1899. Miss Day's painstaking care, and the exceptional facilities afforded by the great libraries clustered about Boston and the interest in her work of the members of the New England Botanical Club, have resulted in the compilation of a bibliographic aid which should be in every botanical library in the country. T.

Botanical Notes. — The *Tenth Annual Report* of the President of Columbia University states that the herbarium and the principal part of the botanical library of that institution have been transferred to the New York Botanical Garden, while for the future the advanced work in botany of the University will be carried on in the laboratories of the Garden. By this combination of the resources of the University with those of the Garden, the latter gains, it is stated, at the beginning of its career, a scientific equipment and a scientific importance which otherwise it could hope to achieve only slowly, while the University receives at once the advantage of the added facilities of the Garden, which, now considerable, will become of the greatest importance as the years go on. The Garden has inaugurated a new publication, under the title of *Journal*, which is intended to give popular information on the development and work of the establishment, and is to be edited by Dr. MacDougal.

The "Talcott Arboretum" of Mount Holyoke College, as appears from a recent number of *American Gardening*, is a glazed structure covering 6430 square feet and with a maximum height of 27 feet 9 inches.

The question of the classification of odors and their use in distinguishing things is again raised by W. C. Alpers in a paper on "Odor Standards," in the *Proceedings of the American Pharmaceutical Association*, Vol. XLVII, p. 221. He suggests a classification for the use of pharmacists, based on the chemical compounds which produce the odor sensations by reacting on the olfactory serum. Odor classifications, like that of Linnæus, and that of flower odors by Delpino, have their value at present, but rest on a more indefinite foundation than that proposed by Mr. Alpers. Kerner has given

[1] Day, M. A. *The Local Floras of New England.* 8vo, 28 pp. Cambridge, 1899. 35 cents.

such a preliminary classification of flower odors in his *Pflanzenleben*; but, as Mr. Alpers intimates, "a new field of research is spread before us for unlimited work" on the composition of volatile substances before a classification approaching perfection can be made.

J. B. S. Norton.

Erythea, a wide-awake journal devoted largely to Western American botany, which has existed for seven years, is to be closed with the final part for 1899. It will be missed in many libraries, and yet the problem of the bibliographer will be simplified by a reduction in the number of journals that he must keep track of.

Part XXI of *Pittonia* for July to December, 1899, contains the following papers by Professor Greene: "A Decade of New Gutierrezias," "Some Western Species of Xanthium," "Four New Violets," "New or Noteworthy Species," XXV–XXVI, "Segregates of *Caltha leptosepala*," "New Species of Arenaria," and "West American Asperifoliæ," IV.

Part III, second series, of *Minnesota Botanical Studies* contains two articles on algæ, two on lichens, and synonymic conspectuses of the native and garden Aconitums and Aquilegias of North America.

Cratægus, a genus in which species-splitting has heretofore been restricted to a rather remarkable degree, is proving to comprise a very large number of apparently separable forms as represented in North America, and Mr. C. D. Beadle, of the Biltmore estate, publishes in the *Botanical Gazette* for January a first instalment of studies in this genus, in which seven species are described as new. In fact, it appears as if almost anywhere in the middle South and West a half dozen nondescript red haws can be picked up in a day's botanizing, in their fruiting season, in autumn.

Mitella, of the trifida section, is passed in review by Piper in *Erythea* for December, with the result that four new species are described.

The Umbelliferæ of Mexico and Central America are treated in an excellent paper by Coulter and Rose, issued in January as a brochure comprising pp. 111–159 of the first volume of the *Proceedings* of the Washington Academy of Sciences.

Rhodora for January contains an editorial note and a series of short articles on the dwarf mistletoe, *Arceuthobium pusillum*, in New England.

A systematic revision of the genus Najas, by A. B. Rendle, constitutes Vol. V, Part XII, of the current series of botanical *Transactions* of the Linnæan Society of London, issued in December.

A morphological and anatomical study of *Pogonia ophioglossoides* is published by Holm in the *American Journal of Science* for January.

Several new grasses from Pringle's Mexican collection of 1899 are described by Scribner in *Circular No. 19* of the Division of Agrostology of the United States Department of Agriculture.

Professor von Wettstein contributes a paper on the pistillate flower of Ginkgo to the December number of the *Oesterreichische Botanische Zeitschrift*, in which he regards the flower as an axillary bud with two transverse carpels.

Professor Thaxter, whose thorough work in the Laboulbeniaceæ has given him a most enviable reputation, publishes in a recent number of the *Proceedings* of the American Academy of Arts and Sciences diagnoses of a large number of new species of the typical genus Laboulbenia, preliminary to a supplement to his monograph of the order.

The subject of plants injurious to stock, on which considerable work has been done by American botanists, is further discussed by Mr. Carruthers, the consulting botanist of the Royal Agricultural Society of England, in No. 40 of the *Journal* of that society. A note by Dr. Labesse, in Vol. XVIII of the *Bulletin* of the Société d'études scientifiques d'Angers, shows that in France the tubers of *Œnanthe crocata* are a source of considerable danger to stock.

Der Tropenpflanzer for January contains an interesting illustrated article by H. J. Boeken on the growth and preparation of fiber from *Agave sisalana*, in Yucatan.

The *Botanical Magazine* of Tokyo for December contains a portrait of the late Professor R. Yatabe. Professor Yatabe was trained at Cornell University, and was well known to many American students a quarter of a century ago, before returning to his native country, where he exerted an important influence in the development of the botanical work of the great Tokyo University.

A biographical sketch of H. G. Bloomer, with portrait, is published by Jepson in *Erythea* for December.

NEWS.

Dr. Ernst Ebromayer, professor of forestry in the University of Munich, has resigned.

The Supreme Court of Missouri has allowed the Shaw Botanical Gardens to sell a portion of their unproductive real estate. With the proceeds about twenty acres will be added to the gardens.

The Society of American Bacteriologists was organized at New Haven during Christmas week with a membership of over thirty. Professor W. T. Sedgwick was elected president, and Professor H. W. Conn, of Middletown, Conn., secretary for the coming year.

We hear from *Science* that the manuscript of a new edition of Coues's Key to North American Birds was left by the late Dr. Coues in a finished condition.

Appointments: Dr. Hugo Berger, professor of physiography in the University of Leipzig. — Dr. J. W. Gregory, of London, professor of geology in the University of Melbourne, Australia. — Dr. Hunnberg, privat docent for anatomy in the university at Giessen. — Dr. L. Hiltner, head of the bacteriological laboratory of the health office in Berlin. — Dr. E. Jacky, assistant in botany in Proskau. — W. L. Jepson, associate professor of botany in the University of California. — Dr. Itefan Jentys, professor of botany in the University of Agram. — Dr. J. C. Klinge, head botanist of the botanical gardens at St. Petersburg. — Mr. Frank Leney, of the British Museum, assistant curator of the museum at Norwich, England. — Dr. D. W. Merill, assistant in biology in the University of Rochester. — Dr. Benjamin Lincoln Robinson, Gray professor of botany in Havard University. — Dr. George Howard Parker, assistant professor of zoölogy in Harvard University. — Dr. G. Tanfiljen, head botanist in the botanical institute at St. Petersburg. — J. L. Luckett, demonstrator of physiology in the University of Cambridge. — Dr. Karl Wenle, docent for ethnology in the University of St. Petersburg.

Deaths: Count Wladimir Dzieduszycki, curator of the Lemburg Natural History Museum, in Galicia, September 19, aged 71. — Dr. Thomas Egleston, emeritus professor of mineralogy in Columbia University, in New York, January 15. — Dr. Henry Hicks, English geologist, November 18, aged 62. — Dr. Paul Knuth, professor of botany in the University of Kiel, October 30, aged 45. — William Pamplin, an English botanist, August 9, aged 92.

(*No. 398 was mailed February 28.*)

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CONTENTS

			PAGE
I.	The Relation of Fungus and Alga in Lichens	GEORGE JAMES PEIRCE	245
II.	A Flagellated Heliozoan	HOWARD CRAWLEY	255
III.	Reactions of Infusoria to Chemicals: A Criticism	H. S. JENNINGS	259
IV.	The Basal Segments of the Hexapod Leg	L. B. WALTON	267
V.	Notes on the Psychology of Fishes	R. W. SHUFELDT	275
VI.	A New Museum Tablet	FRANK C. BAKER	283
VII.	The Lower and Middle Sonoran Zones in Arizona and New Mexico	T. D. A. COCKERELL	285
VIII.	Synopses of North-American Invertebrates. VIII. The Isopoda, Part II	HARRIET RICHARDSON	295
IX.	Reviews of Recent Literature: *Anthropology,* Annual Report of the Smithsonian Institution, Anthropological Notes — *Zoölogy,* Beasts, Lake Urmi, Reissner's Fibre, Preliminary List of the Mammals of New York, The Trail of the Sandhill Stag, Structure in the Mammalian Egg, Bob, Our Native Birds, The Tree Frog, The Protoplasm of the Salmon Egg, Embryology of Invertebrates, A Recent Book on Insects, Sheep Tick, Nauplius Stage of Penæus, Sense Organs of Nereis, Breeding Infusoria, Swiss Infusoria, Growth in the Rhizopodan Shell, Abyssal Rhizopoda, A New Colonial Flagellate, Sporulation in Amœba, Notes — *Botany,* The Cyclopedia of American Horticulture		311, 314, 335
X.	Publications Received		337

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THE RELATION OF FUNGUS AND ALGA IN LICHENS.

GEORGE JAMES PEIRCE.

IF one did not constantly read, even in the newest text-books for older[1] as well as for younger students,[2] that the association between fungus and alga in lichens is uninjurious to the latter, I should not feel impelled to add to the already volumi-

[1] See *Text-book of Botany*, by Strasburger, Noll, Schenck, Schimper, translated by Porter (Macmillan Company, 1898), p. 375: The fungus derives its nourishment saprophytically from the organic matter produced by the assimilating alga, without at the same time behaving as a parasite and injuriously interfering with its vegetative activity.

In the fourth German edition (received by me, Jan. 19, 1900, as a separate) Schenck says, p. 336: Was das Verhältniss von Pilz zu Alge anbelangt, so umspinnt der Pilz mit seinem Mycel die Algenzellen, schliesst sie in ein Hyphengewebe ein und ernährt sich von den durch die assimilirenden grünen Algenzellen erzeugten organischen Stoffen; er kann aber Haustorien in die Algenzellen hinein entsenden und sogar deren Inhalt aufzehren.

[2] See Coulter's *Plant Structures* (D. Appleton & Co., 1899), p. 80: In the case of lichens the symbionts are thought by some to be mutually helpful, the alga manufacturing food for the fungus, and the fungus providing protection and water containing food materials for the alga. Others do not recognize any special benefit to the alga, and see in a lichen simply a parasitic fungus living on the products of an alga. In any event the algæ are not destroyed, but seem to thrive.

nous discussion of symbiosis in lichens. In spite of all the evidence, old and new, and in spite of common sense, the lichens are only too often described as furnishing the most perfect examples of the mutually beneficial association of two utterly different kinds of organisms, — one of these able to lead a normal and perfect existence when by itself, the other absolutely dependent for food upon other organisms, living or dead. Let me, therefore, once more direct the attention of biologists to a scrutiny of these peculiar forms.

Every one now admits that lichens consist of two distinct and separable parts, of colorless fungus-like hyphæ, which form the greater part of the mass of the lichen, and of chlorophyll-containing alga-like cells, known as gonidia. Repeatedly it has been shown that the gonidia of lichens are not merely alga-like, but are algæ, often found free in nature, growing not only on the same surfaces as furnish the seat of attachment of lichens, but on many others also, growing and multiplying as healthy individuals whenever external conditions make active life possible, passing over other periods in one or another of the resting conditions known to biologists. No one now questions that lichen gonidia are algæ, and that with due care gonidia can be identified with already known species of algæ found outside of lichen associations. Identification on mere inspection of the gonidia in the lichen is not always possible, nor would it always be correct. For example, Hedlund[1] says that the alga which forms the gonidia in species of Micaria usually looks like Glœocapsa and frequently occurs on rotten wood, but that, when cultivated on this wood under abundant illumination and free from fungus enemies or algal competitors, the alga multiplies rapidly, becomes deep green, the daughter-cells separate, and none has the thick gelatinized wall which is one of the characters of Glœocapsa. Conditions wholly external to the algal cells, especially such influences as affect their freedom, cause these cells to depart from their Protococcus type and to develop qualities and habits characteristic of a wholly

[1] Hedlund, T. Kritische Bemerkungen über einige Arten der Flechtengattungen Lecanora, Lecidea, und Micarea. *Bihang till K. Svenska Vet. Akad. Handlingar*, Bd. xviii. Stockholm, 1892.

different genus. Assuming that Hedlund's experiments were conducted with sufficient cleanliness to prevent Protococcus from replacing Glœocapsa, this return from Glœocapsa-like characters to the original Protococcus characters is interesting evidence of the influence of living competitors (other algæ) and enemies (fungi), as well as of lifeless forces (light, food, etc.), upon the appearance of living organisms. Since small algæ are so modified, both inside and outside of the lichen body, by external influences, their identification and the identification of gonidia become in some instances matters of difficulty, in which experiment must play an important part.

As to the fungus-like component of lichens, all are now agreed that the hyphæ are fungus, but the identity of any fungus component of lichens with species of fungi living otherwise is difficult to prove and is absolutely denied by many. According to Reinke,[1] the fungus components of the lichens of to-day came from fungi no longer existing as distinct species. That this is necessarily true it is impossible to see; that it is true is hard to believe, for, as has been shown above for the gonidia, the other organisms with which it is associated, as well as the lifeless forces to which it is subjected, may so influence an organism that its appearance and behavior will be profoundly modified. Although Möller's[2] now classical experiments in cultivating the fungus components of certain simple lichens on artificial media were successful as far as they went, they did not go so far as to show that the fungus could reproduce itself by ascospores formed in normal apothecia, and, after all, only lichens of simple thallus form were cultivated at all. It is only natural, but also greatly to be regretted, that the extremely slow growth of lichens and of their fungus components has deterred most botanists from experimenting on these interesting plants. Reinke's view can be proved or disproved only by successful culture of

[1] Reinke, J. Abhandlungen über Flechten, III. *Jahrb. f. Wiss. Bot.*, Bd. xxviii (1895), p. 64: Kein Flechtenpilz ist bisher im freilebenden Zustande beobachtet worden — abgesehen von den Basidiolichenen — und es hat demnach den Anschein, dass alle Pilze, aus denen sich Flechten entwickelt haben, als Pilze zu Grunde gegangen sind.

[2] Möller, A. Ueber die Cultur flechtenbildender Ascomyceter ohne Algen. *Inaug. Diss.* Münster, 1887.

the fungus from spore to spore, and whether or not we believe with him that the fungus components of lichens no longer exist by themselves in nature, we certainly must call them fungi.

What is a fungus? However a systematist might answer this question, a physiologist would say that a fungus is a low dependent plant, demanding at least non-nitrogenous food in a state of comparatively high elaboration (sugar, fat, oil, or similar carbon compounds), since it is unable to manufacture such food for itself. It follows, therefore, that a fungus must be either parasitic or saprophytic, or, to follow the newer terminology,[1] metatrophic or paratrophic. When a fungus enters into association with an alga to form a lichen, the fungus allies itself with an independent plant, one able to manufacture all of its own food. The lichen is then composed of a dependent plant which must receive elaborated food, and of an independent plant which needs only food materials and light in order to take care of itself. What then is the nature of the association between these two? Reinke[2] and his sympathizers believe (*a*) that the association is consortism; (*b*) that the two members of the consortium are dependent upon and beneficial to each other; and (*c*) that the consortium is autonomous. On the other hand, many botanists, probably in the minority at the present moment, see in this association not a mutually advantageous association, but the parasitism of one plant upon another. Reinke,[3] de Bary,[4] and many others assert that the association of fungus with alga in lichens cannot be simple parasitism because, if this were the case, the fungus would consume the alga, and that would be the end of the association. Such a conclusion is not required by the evidence. It must first be shown that the influence of the fungus is so violent and so exhausting that the alga is not able, by producing slightly more food, by refraining from less economical ways of repro-

[1] Fischer, A. Vorlesungen über Bakterien, pp. 47, 48. Jena, 1897.

[2] Reinke, J. Abhandlungen über Flechten. II. Die Stellung der Flechten im Pflanzensystem. *Jahrb. f. Wiss. Bot.*, Bd. xxvi, pp. 524–542, 1894.

[3] Reinke, J. *Loc. cit.*, Bd. xxvi, p. 530, etc.

[4] de Bary, A. Die Erscheinung der Symbiose. Strassburg, 1879.

duction (*e.g.*, zoöspore formation), by dividing in certain planes instead of in others, etc., to meet the extra demand made upon it by the fungus and to form some cells which are affected only indirectly, if at all, by the fungus.[1]

On these points a few remarks may be made. In the first place, those algæ which form the gonidia of lichens will grow and multiply faster under almost any conditions than the fungus, and they grow and multiply in lichens less rapidly than under favorable conditions outside. In the lichen itself they grow and multiply very rapidly at times, much more rapidly than the fungus. For example, the gonidia in a fragment of *Ramalina reticulata*, the California lace-lichen, may be made to grow and to divide very rapidly by placing the piece in water in the comparative warmth of the laboratory in winter. The whole lichen does not grow; only the gonidia multiply and grow; the fungus grows but little, if at all. Out of doors such conditions frequently occur in all lichens. During warm rains or fogs, or dews, the gonidia have the advantage; they multiply and grow much more rapidly than the fungus; many gonidial cells recover what they had lost by too intimate association with the fungus. In this way new generations of gonidial cells are produced which continue the race in the lichen body and thereby prevent the fungus from devouring all at once. In other words, though the fungus may be parasitic upon the alga, the more vigorous alga is not wholly and at once consumed by its parasite, whatever may be the ultimate fate of the gonidial cells one by one.

Having seen that the association of fungus and alga in lichens is not destructive to all the algal cells at once, it must be shown whether the fungus is destructive or injurious to any. In all lichens the hyphæ and gonidia are in most intimate contact, the hyphæ either closely clasping the gonidial cells or filaments, or actually sending one or more haustoria into the separate gonidial cells. As a result of such intimate contact, osmotic movement of food and other substances must take

[1] Hedlund, T. *Loc. cit.* Peirce, G. J. The Nature of the Association of Alga and Fungus in Lichens. *Proc. Cal. Acad. Sci.*, Third Series, Botany, vol. i, No. 7, 1899.

place between the hyphæ and the invested gonidia. That such a movement does not take place it is impossible to believe unless one assume that the nature of the limiting membranes of algal and fungal cells is such that osmosis is a physical impossibility. This assumption would be self-destructive, however, for if these membranes were impervious to the dissolved substances in the algal and fungal cells, all osmosis would be impossible, and the cells would all die from lack of food and water. There must then be osmotic movement between fungus and alga. In obedience to the ordinary laws of osmosis there would be movement of dissolved substances from regions of more to regions containing fewer molecules of these substances. The alga under the influence of light manufactures complex nutritious non-nitrogenous carbon compounds, which are at times, if not always, in soluble forms. These substances would tend to migrate from the algal to the fungal cells. This physical phenomenon is of the utmost physiological importance to the fungus, for it thereby gains the food it needs. Such a transfer is inevitable so long as the conditions of intimate contact, of permeable membranes, of supply of food and demand for it continue the same. If the demand for food by the fungus or any part of it exceed the ability of the alga, or of any algal cell, to manufacture enough for its own needs and those of the fungus, the fungus will consume the alga itself. The numbers of empty gonidial cells in the lichen body are sufficient evidence of this,[1] but this evidence cannot always be found, for only at times does the fungus demand so much of the alga that the body substance of the alga must be given to feed the fungus.

The slow-growing fungus component of the lichen draws food from the more rapidly growing algal cells in which the food is manufactured. Such taking of food is evidently parasitism. It can be nothing else. The intimacy of contact of hyphæ and gonidia precludes any other supposition than that the hyphæ osmotically draw food from the necessary and helpless algæ. If the algæ grew and multiplied less rapidly, or if the fungus grew more rapidly, or if the alga made less and the fungus demanded more food, or even if fungus and alga always

[1] Peirce, G. J. *Loc. cit.*, p. 225, etc.

grew at a constant rate instead of the alga sometimes growing much faster than the fungus, the parasitism of fungus on alga would result much sooner in the destruction of each algal cell. As it is, the fungus destroys the algæ, but only by degrees, and so slowly that a new generation is mature before the first is consumed.

If there is osmotic transfer of non-nitrogenous food from alga to fungus, there may also be osmotic transfer of something else from fungus to alga. Presumably there is. De Bary, Reinke, and others say that the fungus supplies the alga with water and mineral salts. Undoubtedly this is true, but I doubt this being other than by the capillary movement of columns or films of water, holding mineral salts in solution, between and along the hyphæ which, running more or less parallel with one another, form continuous capillary tubes from the substratum throughout the body of the lichen. By this means the fungus certainly does supply the alga, but so would cotton fibres or glass tubes similarly placed. It cannot be questioned that, in its position in the lichen, the alga needs to have water and mineral salts conducted to it, but its position is not of its own seeking, natural, or necessary, or at all evidently advantageous. In its natural habitat the alga (Protococcus, Glœocapsa, Nostoc, etc.) could supply itself with aqueous solutions of needed food materials without the intervention of a dearly paid servant.

It is alleged by some that what the fungus obtains from the alga is merely the excess of organic matter elaborated by the latter, and that the alga is manured by the waste substances produced by the fungus. Such conceptions of the physiology of living organisms are anything but definite. According to this, plant cells and plant bodies are leaky affairs from which nutritious substances ooze in appreciable quantities. Every one knows that this is not true. The ooze theory of the nutrition of the associates in the lichen must, therefore, be abandoned.

It is said that, if the fungus were simply parasitic upon the alga, the algal cells would not so rapidly multiply, would not look so healthy as they often do in the lichen thallus. Besides the reason already given for this, it seems to me certain, from my study of *Ramalina reticulata*, and of some others

of our California lichens,[1] that the algal cells invested or penetrated by fungus filaments try by frequent division to produce cells which shall be quite free from contact with hyphæ. The contact of the hypha exerts an irritation which induces more frequent division, and at a smaller size than normally takes place in gonidia not in contact with hyphæ. Gonidia may frequently be found in the lichen thallus, large and wholly free from contact with hyphæ. These gonidia divide less frequently than the others and are by all means nearest the typical algal cells of the same species in size, color, form, thickness, and composition of wall, etc. These free gonidia are fed with water and mineral salts, are protected against drought and certain other dangers, and may really benefit by being enclosed in a mass of fungus hyphæ. Gonidia which are not merely loosely enclosed in the lichen body but are tightly invested if not penetrated by hyphæ, although they may be supplied with food materials and may be protected, are also robbed of part of the food they elaborate and are actually irritated by their associate. That they are ultimately sucked dry by the fungus I have recently shown in the paper already referred to.

In an increasing number of lichens it is being found that the hyphæ not merely closely invest the gonidia, thereby making possible the osmotic movement of elaborated food from alga to fungus, but that the hyphæ actually penetrate the gonidia by haustoria. These haustoria either apparently merely penetrate the cell-wall, pushing back the protoplasm, or they actually penetrate the protoplasm also. Where it is possible to demonstrate in any species of lichen that haustoria actually occur in the gonidia, there can be no doubt that the association is of unmixed injury to the alga, and of unmixed benefit to the fungus. The movement of aqueous solutions through the haustoria from the gonidia to the hyphæ is different, however, only slightly in degree and not at all in kind from that which takes place between gonidia and closely clasping hyphal branches. The absorption of food is easier, the parasitism more perfect and more evident, when haustoria connect hyphæ and gonidia

[1] Peirce, G. J. *Loc. cit.*

than when the hyphæ merely enclose the gonidia, but the hyphæ are parasitic in both cases.

The foregoing argument, based on observations reported in detail elsewhere,[1] shows, I believe, that there are no physiological or structural reasons for supposing that the association of fungus and alga in lichens is other than the actual parasitism of the former upon the latter. If the lichens are merely fungi and algæ associated together as parasite and host, these associations are no less remarkable and interesting, though less moral, than if they were ideal alliances for mutual aid. Experiment has still to show whether the characters of the lichen thallus are formed by the fungus mainly, or by the fungus under the influence of its host, how far substratum, illumination, nutrition, etc., affect the character of the association. Experimentation on lichens demands endless patience and considerable skill, for lichens grow with prodigious slowness, and the chances of a culture becoming infested with mould or bacteria before it has accomplished the purpose designed are only too great. Some of the problems puzzling systematic lichenologists can be solved only when illuminated by experimental culture of the fungus component of the lichen thallus under definitely known conditions.

STANFORD UNIVERSITY, CALIFORNIA,
January, 1900.

[1] Peirce, G. J. *Loc. cit.*

A FLAGELLATED HELIOZOAN.

HOWARD CRAWLEY.

In some water taken from the pond in the Botanical Gardens at the University of Pennsylvania, in August, 1899, the two Heliozoa here figured were found.

Of these, that shown in Fig. 1 possessed a typical heliozoan body of foamy protoplasm. There was a clear, colorless outer layer, while the central portion consisted of an aggregation of small spherical bodies, greenish, reddish, and yellowish in color. The nucleus was invisible, and a contractile vacuole was not observed.

The most striking feature of the animal was the pseudopodia. These were of two kinds. The longer closely resembled those of Actinophrys. They projected in a more or less radial direction and showed considerable freedom of movement, frequently sweeping through large arcs. They always, however, preserved their straightness. At different times they varied greatly in length, and were often wholly withdrawn.

The shorter pseudopodia were extremely delicate strands of protoplasm that projected radially from the surface of the animal. The outer end of each of these was modified in such a way as to render it more conspicuous, but I was not able to determine the exact nature of this modification. In the specimens that were observed, the entire system moved in concert, the movement consisting in an alternate lengthening and shortening of the pseudopodia. Fig. 1 shows them at the greatest length that I observed. In such cases the spherical body of the animal appeared as if inclosed by a definite ring. At other times these pseudopodia were wholly withdrawn.

The animal was highly polymorphic, and occasionally, when all the pseudopodia of both kinds were drawn in, its shape departed so far from the spherical that it might have been taken for a sluggish Amœba.

On account of the clear cortical layer, the color of the central mass, the two kinds of pseudopodia and the nature of their movements, and the invisibility of the nucleus, the animal bears a close resemblance to *Vampyrella lateritia*, as described by Leidy ("The Fresh-Water Rhizopods of North America," *U. S. Geol. Sur.*, Vol. XII, Washington, 1879). There is a discrepancy in the nature of the terminal modifications of the shorter pseudopodia. Leidy states that these resemble the head of a pin, which was not the case in the

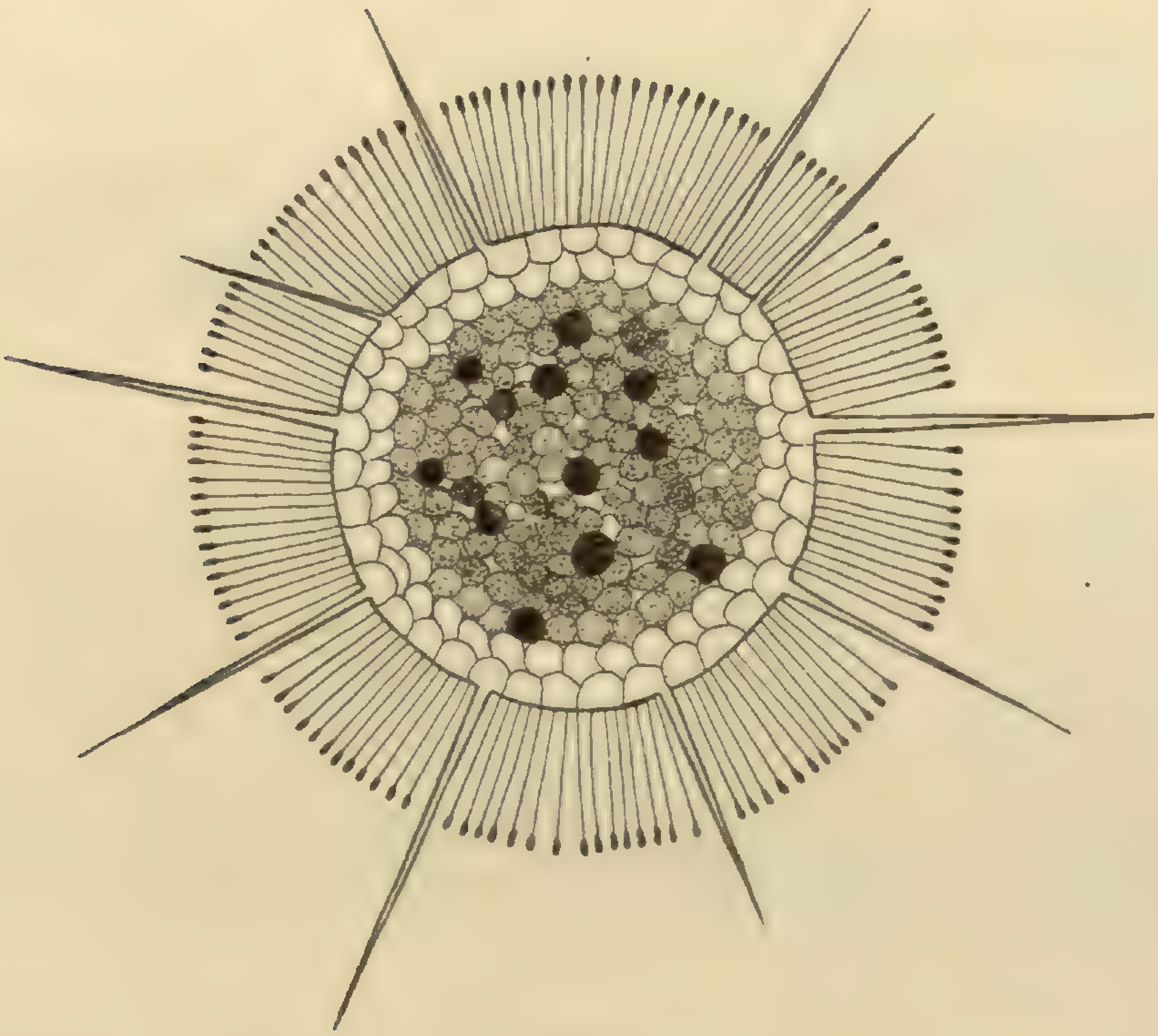


FIG. 1.

animal that I found. Nevertheless, the appearances tally so closely in all other respects that it may be referred to that genus.

The second heliozoan, shown in Fig. 2, was exactly like the first in all respects but one. The size, 80 μ in diameter, was the same. The long pseudopodia were identical in both animals, and the bodies, with their clear cortices and colored central masses, wholly alike. The difference consisted in the fact that the short pseudopodia of the form shown in Fig. 1 were represented in the other by a mantle of flagella. This whole system moved in unison, but the movement of each individual proto-

plasmic process was the lashing of a flagellum, and not the beating of a cilium.

While the spores of Heliozoa are in several cases flagellula, the possession of a series of flagella by the adult forms has been noted in but one other case. Eugène Penard ("Sur un heliozoaire nageur, Myriophrys paradoxa, *gen. nov.*, *sp. nov.*," *Arch. Sci. Phys. et Nat.*, Tome IV, No. 9, pp. 285–289, Pl. III, 15 Septembre, 1897) describes a single individual which he

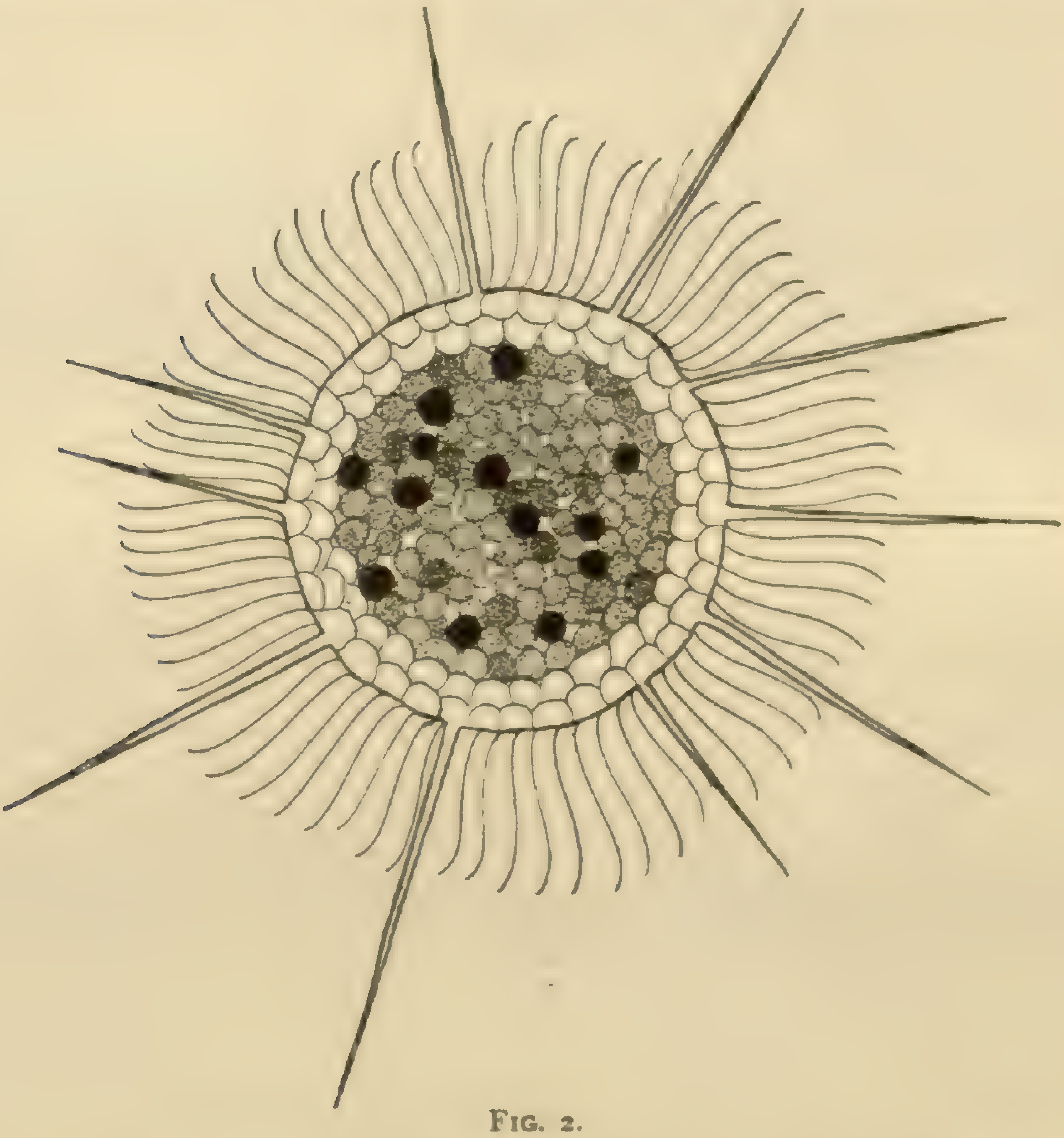


FIG. 2.

found in fresh water, also in August. This animal was about 40 μ in diameter. It was furnished with pseudopodia of the Acanthocystis type, and possessed an external skeletal layer beset with minute scales (*écailles*). There was a large contractile vacuole and an evident nucleus. It therefore will be seen that in several essential characters it differed wholly from the form here described. Concerning the flagella, Penard says: "On pourrait plutôt comparer ces cils à de petits flagellums, qui, par leur abondance, formeraient une véritable chevelure."

Penard considered the flagellated condition to be permanent,

and created for the organism a new genus and a new species. He saw, however, but one individual. I was more fortunate in that I found many individuals of the two kinds that I have figured.

It is known that a pseudopodium may turn into a flagellum, and, conversely, that a flagellum may turn into a pseudopodium. This, together with the fact that these two animals were identical in all respects but one, and that they occurred side by side in the same drop of water, renders it very probable that they are only different conditions of one and the same animal. There seems, then, no good reason for creating a new name, and I accordingly suggest retaining that used by Leidy, *Vampyrella lateritia*, even though the definition of this species must be somewhat enlarged.

Harvard University, Feb. 5, 1900.

REACTIONS OF INFUSORIA TO CHEMICALS: A CRITICISM.

H. S. JENNINGS.

In the January number of the *American Journal of Physiology*, Garrey [1] gives the results of extended experiments on the effects of chemicals in causing motor reactions in the flagellate Chilomonas. From the chemical side the paper is a valuable one, as being the most thorough study yet made of the specific effects of chemicals in causing reactions in unicellular organisms, and in treating the subject from the standpoint of modern physical chemistry. On the other hand, that portion of the paper which treats of the part played in the reactions by the organisms seems to me much less successful, and it is my purpose to point out certain criticisms on this part of the work.

Garrey found that the motor reactions of Chilomonas are set strongly in operation by certain chemicals, "very swift shooting movements being induced," so that the organisms, as a result of these movements, soon leave the sphere of influence of the substance in question. This effect is termed by Garrey "chemokinesis"; it is analogous to that which I have called "negative chemotaxis" in Paramecium. The chief portion of the paper is devoted to determining the relative strength of various chemicals in causing this reaction, and the exact factors in the solutions that produce the effect; interesting and valuable results are here brought out.

In certain organic acids (acetic, butyric, lactic) and their salts Garrey found the flagellates to form aggregations, as Paramecium does in solutions of CO_2 and acids of all sorts; [2]

[1] Garrey, Walter E. The Effects of Ions upon the Aggregation of Flagellated Infusoria. *Amer. Journ. of Phys.*, vol. iii, pp. 291–315.

[2] Owing to the failure of his attempts to repeat my experiments with solutions of CO_2 and inorganic acids, Garrey denies my results with Paramecia. His failure was unquestionably due to neglect to fulfill the necessary experimental conditions. I have never known the experiments to fail when properly carried out.

these aggregations, he says, are due to "true chemotropism." In that portion of the work which deals with the way in which these aggregations are formed and with the part played by the organism, it seems to me that Garrey neglects certain facts that are absolutely fatal to the view of these matters which he puts forth. He did not determine the mechanism of the reactions of Chilomonas, — the exact way in which the organism moves when stimulated, — and this seems to me the first requisite for an understanding of how the reactions are brought about. Garrey's point of departure is his definition of *tropism* (which he says is the same as *taxis*).

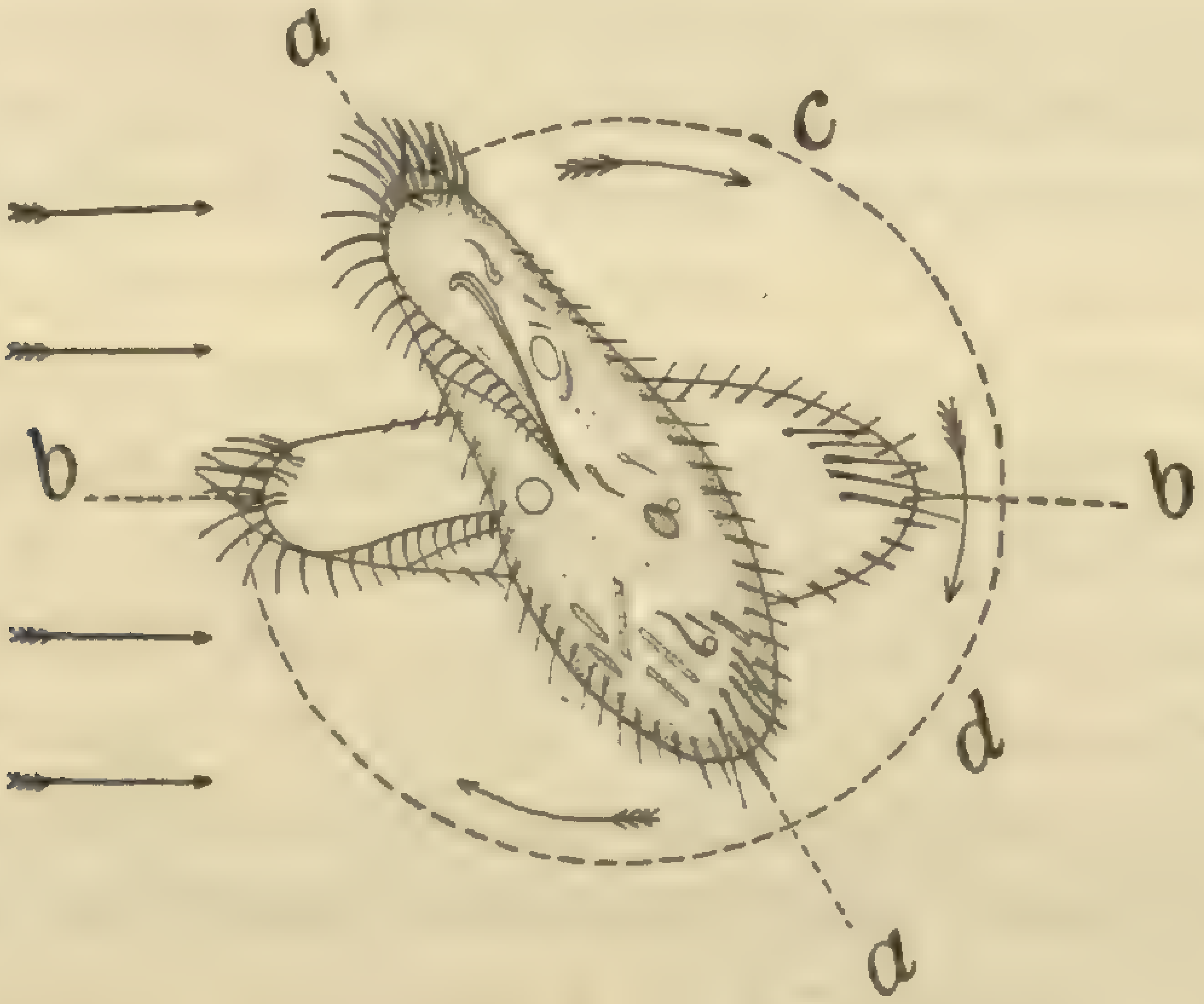
Taking heliotropism as a type, he says: "In heliotropism the organism is so oriented that its axis or plane of symmetry coincides with the direction of the rays, and symmetrical points on the surface of the body are struck by the light rays at the same angle." He then quotes with approval, for the case of chemotropism, Professor Loeb's generalization: "The essence of chemotropic orientation would then consist in the animals placing themselves in such a position that symmetrical points on the surface of the body are cut by the diffusion lines at the same angle." The movement of Chilomonas into drops of organic acid, Garrey says, is "true chemotropism," and he states that the organisms move toward the center of diffusion "as if orienting themselves to radially disposed lines; lines which may represent the paths of diffusing molecules or ions." From this one might infer that Chilomonas actually does so orient itself "that symmetrical points on the surface of the body are cut by the diffusion lines at the same angle," and then swims forward in this position, as required by the generalization; Garrey says nothing to the contrary. Yet the animal does nothing of the sort. The very elementary fact seems to have escaped Garrey that Chilomonas, as is well known, is *unsymmetrical*, so that it is impossible for it to orient itself in this manner; there *are* no such symmetrical points to be thus cut. (In Chilomonas the so-called "upper" or larger lip lies at the dorso-dextral angle of the anterior end, as will be seen by consulting Fig. 9 *b* of Pl. XLV of Bütschli's *Protozoa*, so that the animal is unsymmetrical both dorso-ventrally and dextro-

sinistrally.) Furthermore, observation of its movements shows that it makes no attempt to do the impossible; instead of retaining any such position as the generalization calls for, it swims in spirals, a certain side of the animal being always toward the inside of the spiral; as Bütschli says, they "describe rather narrow circles" (Bütschli, *Flagellata*, p. 853). These facts, of the lack of symmetry of the organism, and its swimming in spirals, might be thought to be facts of capital importance for a decision as to whether it falls under Professor Loeb's generalization or not; they are nowhere mentioned by Garrey. It is well known that the Infusoria are prevailingly unsymmetrical, so that it is quite impossible for most of them to fall within this generalization. An attempt to apply it to one of the Hypotricha, for example (see figure on p. 262), where not only the form of the body but the structure and distribution of the locomotor organs are strikingly unsymmetrical, would bring out the absurdity of the attempt, and observation of the actual movements of the organisms, as detailed in the Fifth of my Studies,[1] only accentuates the impossibility. It may be regarded as axiomatic that a principle which requires the symmetry of organisms cannot be applied to organisms that are unsymmetrical. On this account I have not previously considered it worth while, in my Studies on Reactions, etc., to show the relation of Professor Loeb's well-known generalization to the movements of the prevailingly unsymmetrical Infusoria. The generalization was evidently made from a study of bilaterally symmetrical animals, and may be of the greatest value for an interpretation of their activities; it is obviously inapplicable to unsymmetrical organisms.

I have described the mechanism of the motor reactions of Chilomonas, on pp. 231–234 of the same number of the *American Journal of Physiology*, as that in which Garrey's paper appeared. Later study of their reactions in the production of the aggregations described by Garrey has convinced me that these aggregations are produced through the mechanism of the described motor reaction, in a manner exactly analogous to the production of the similar aggregations of Paramecium in weak

[1] *Amer. Journ. of Phys.*, vol. iii, p. 249.

acids, described on pp. 314, 315, of the Second of my Studies.[1] This possibility is not discussed by Garrey, apparently because of a preconceived view that chemotropism must take place according to Professor Loeb's generalization above quoted. He says: "Jennings's motor reaction cannot account for orientation," and, therefore, that it has nothing to do with tropisms. This unsupported sweeping denial seems a peculiar way of meeting such a detailed account of the production of orientation through the motor reaction as I have given for the thermotaxis of Paramecium on pp. 334–336 of the Second of my Studies. The general proposition that a motor reaction cannot cause orientation seems still more remarkable. Consider an organ-



ism, as in the figure, lying obliquely to the line of action of the incoming stimulus, which is indicated by the four straight arrows. Its position is at first *a–a*. After the stimulus has acted for a time, the organism is found to be oriented as shown at *b–b*, with its longitudinal axis in the direction of the lines of force. Now, how can this orientation possibly take place *except* through a motor reaction? The animal has certainly moved under the influence of the stimulus from the position *a–a* to the position *b–b*, and such a movement under the influence of a stimulus is what is commonly known as a motor reaction.[2]

[1] *Amer. Journ. of Phys.*, vol. ii, pp. 311–341.

[2] Garrey's attempt to attribute to me the absurd idea that the principle of a motor reaction is new (*loc. cit.*, p. 313, note), is perhaps unworthy of mention. The comparison of the motor reaction of Paramecium with that of a muscle,

The essential feature of the characteristic motor reaction of these organisms, as I have described it, is that they turn, when they do turn, toward a structurally defined side, whatever the line of action of the stimulus. For example, the organism in the figure (one of the Hypotricha) turns to the right, in the direction indicated by the curve *c–d*. But evidently the organism may come into the position *b–b* as easily by turning to the right as by turning to the left; in the former case it must simply keep turning somewhat longer. As a matter of fact, orientation to most stimuli occurs in the Hypotricha in exactly the manner illustrated — by turning to the right. This is true for chemical, osmotic, mechanical, and thermal stimuli; whether for electric stimuli and light has not been shown.

The precision of the orientation, and whether a large number of organisms will be oriented in the same way, depends upon the question as to what influences produce the motor reaction. Suppose that in the figure the stimulating agent is something that acts steadily in lines coming in the direction of the straight arrows. Now, I have shown in the Fifth of my Studies that many of these organisms are much more sensitive at the anterior end than elsewhere, so that a stimulus at the anterior end produces a different effect from a stimulus elsewhere on the body. When, therefore, the organism is so oriented that the lines of force impinge directly on the anterior end (position *b–b*), it will, of course, be differently affected as compared with a position in which the sensitive anterior end is wholly or partly protected by the remainder of the body. Thus different reactions may be caused in the two cases; in one position the motor reflex may be caused, in the other not. If, for example, the motor reflex is caused when the lines of force impinge on even a small part of the anterior end, then the organism will not cease giving the reaction until it is oriented with anterior end directed away from the side of incoming

which Garrey makes for my information, I had already developed at length to show their identity in character, in two papers (*Amer. Journ. of Phys.*, vol. ii, p. 339; *Amer. Journ. of Psychol.*, vol. x, p. 513). I had counted it a chief result of my work that it had reduced the supposed attractions and repulsions of these organisms to a motor reflex "of the same order as the motor reflexes of higher animals," as I have expressed it elsewhere.

force. If a large number of such organisms are in the field of the force, they will soon all show a common orientation, and when they move they will all move in the same direction. *All that is necessary for orientation to take place in this way is that the organism shall be differently affected when it is in one position from the way it is affected in another position.* It is difficult to imagine any agency that can cause orientation in which this condition is not fulfilled.

When the organism is once oriented with reference to a constant stimulus, of course no further reaction is necessary; it simply keeps up the normal forward motion until this motion brings it into new relations with the stimulus, when the motor reaction is again caused, resulting in a readjustment of orientation. In the hypothetical case above supposed, if the organism swims in a curve instead of a straight line, it will soon come into a position such that the lines of incoming force impinge on the sensitive anterior end; the motor reaction is thereby induced until the animal has come again into the position where the anterior end is not thus affected.

Garrey says: "All these motor reactions have nothing to do with *tropisms*, for these motor reactions are only the expression of a very sudden change in the stimuli, while the characteristic of the tropism is the stationary condition of the stimuli." He fails to consider the fact that, stationary as the stimuli may be, the organisms with which he is dealing are *not* stationary; by their own movements the organisms come into new relations with the stimuli, and these new relations may result in the production of the motor reaction, causing a readjustment of orientation.

To summarize, the chief points which I would make in criticism of Garrey's conclusions are as follows:

1. In all work upon the reactions of organisms to physical and chemical agents, it is necessary to consider the structure and normal activities of the organisms, as well as the nature of the agents acting as stimuli.

2. Orientation such that "symmetrical points on the surface of the body are cut by diffusion lines at the same angle" (or by any other lines at the same angle) is impossible in unsym-

metrical organisms, such as are a large proportion of the Infusoria.

3. Observation of the movements of the Infusoria, both the unsymmetrical and the symmetrical, shows that they do not orient themselves even approximately in the manner above expressed, but that they swim as a rule in spirals, and orientation usually takes place through a motor reflex, characterized by the fact that the organism, when it turns, turns toward a structurally defined side.

4. A sudden change in the stimulus is not necessary to produce a motor reaction, as Garrey has stated, for the organism itself, by moving, comes into new relations with a constant stimulus, and by these new relations the motor reflex may be caused, resulting in a readjustment of orientation.

5. The gatherings of Chilomonas in drops of organic acid, described by Garrey, take place, according to my observations,[1] through the mechanism of the motor reaction of Chilomonas, described in the Fifth of my Studies. Whether this is "true chemotropism" or not depends on the definition of chemotropism.

6. The orientation of Chilomonas takes place through this motor reaction, and in general it is impossible for an unoriented organism to become oriented except through a motor reaction of some sort (except where passively moved, like a dead body).

ANN ARBOR, MICH., Feb. 6, 1900.

[1] The observations on which this statement is based are detailed in a paper by the author in the April number of the *American Journal of Physiology*.

THE BASAL SEGMENTS OF THE HEXAPOD LEG.

L. B. WALTON.

At the base of each leg in the Hexapoda are a series of segments and sclerites which enter into the composition and serve as a support of the appendage. These are the trochanter, *coxa genuina*, meron[1] trochantin, and antecoxal piece. The difficulties in the way of accounting for the origin of these segments and homologizing them in the various orders have caused morphologists more or less trouble.

By reason of the fusion which has taken place between the trochanter and femur in the Myriopoda and Hexapoda, many writers on insect anatomy hold that the trochanter is merely a portion of the femur which has in some manner become constricted so as to form an apparent but not an actual segment. The fusion, however, between the two parts is a specialization acquired during the later embryonic stages of development.[2] A similar case of ankylosis is often noticeable between certain segments of the appendages in Crustacea. Bordage[3] has advanced the theory, from observations based on certain Phasmidæ, that the two segments have become coalesced in the Arthropoda as a result of ecdysis. Since the same fusion, however, is very pronounced in the Myriopoda, particularly among the Diplopoda, where Verhoeff[4] believes the trochanter

[1] In order to distinguish between these two parts, which have been confused under the name "coxa," I have called the piece articulating with the trochanter *coxa genuina*, and the posterior lateral part articulating with the epimeron, meron (from μηρός = thigh), since its lateral margin is always found in articulation with the epimeron.

[2] The "two-jointed trochanter" of Hymenoptera [Terebrantia] appears to be a secondary modification, the lower part ["*apophysis*," Ratzeburg] being derived from the femur. This is the view held by Sharp, *Camb. Nat. Hist.*, vol. v, p. 520.

[3] On the Probable Mode of Formation of the Fusion between the Femur and Trochanter in Arthropoda. *Comptes Rendus de la Société de Biologie*, tome v, No. 28, pp. 839–842, 1898. Also *Ann.* and *Mag. Nat. Hist.*, vol. iii, pp. 159–162, 1899.

[4] Ein Beitrag zur Kenntniss der Glomeriden. 1895.

is in many cases entirely absent, it is evident that it is a characteristic of a primitive stem form, and has not arisen, as Bordage suggests, from an "ancestral form belonging to the existing Phasmids in which there was a distinct articulation between the two consecutive segments."[1] In addition to ecdysis, insisted upon by Bordage,[2] we must take into consideration various other selective factors, chief among which appear to have been mutilations by enemies. The severing of the segments, which resulted from either factor, would prob-

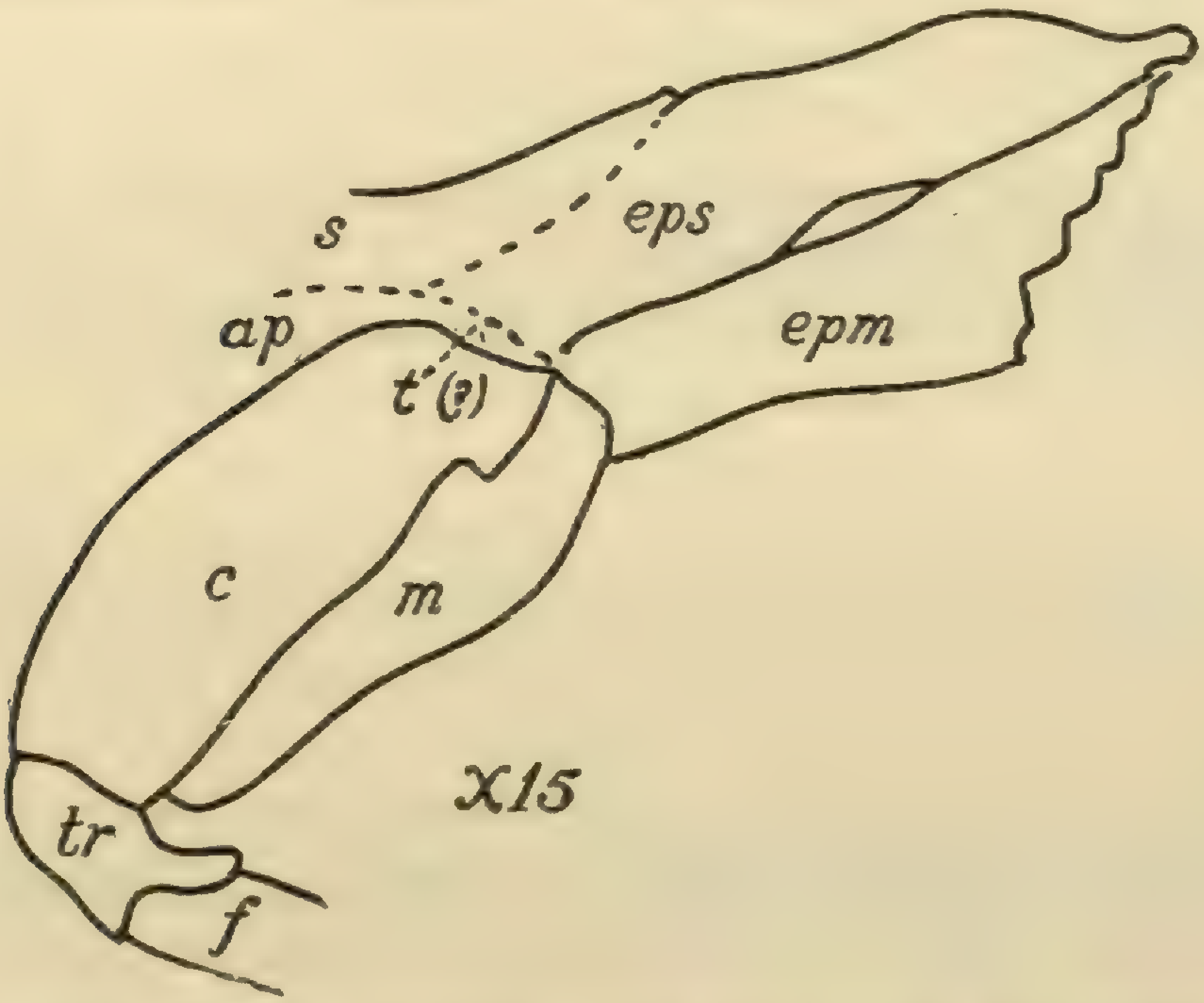


FIG. 1. — *Panorpa communis*. Metathorax; *c*, coxa genuina; *m*, meron; *eps*, episternum; *epm*, epimeron; *ap*, antecoxal piece; *s*, sternum; *t* (?), trochantin; *tr*, trochanter; *f*, femur.

ably occur near the base of the appendage, and the favored forms would be those in which the two segments were approaching the fused condition, the invagination of the chitinous wall preventing undue hemorrhage. Autotomy, which Bordage so fully explains, would undoubtedly play an important part here. It also appears advantageous to poly-

[1] I have adopted the translation as given by Austen.

[2] The position of Bordage in regard to the manner in which the fusion has come about is clearly on the side of Neo-Lamarckianism, since he attributes it to "a mechanical strain," and says that it is an "example of a character acquired by use . . . and then transmitted by heredity." This conclusion, however, as I have endeavored to show, seems unwarranted.

podial forms that a series of the appendages move more or less in unison, and it is obvious that such rhythmic motion is better maintained with the articulation of a coxa and trochanter alone than with an additional articulation between the trochanter and femur. This may be a factor in accounting for the more pronounced fusion of the two segments in the Diplopoda.

In 1893 Hansen[1] endeavored to homologize the trochanter of the Hexapoda with the ischiopodite in Crustacea. This homology was based on the supposition that the part assumed by him to be the trochantin[2] in the Cicadaria (Cicadidæ, Ful-

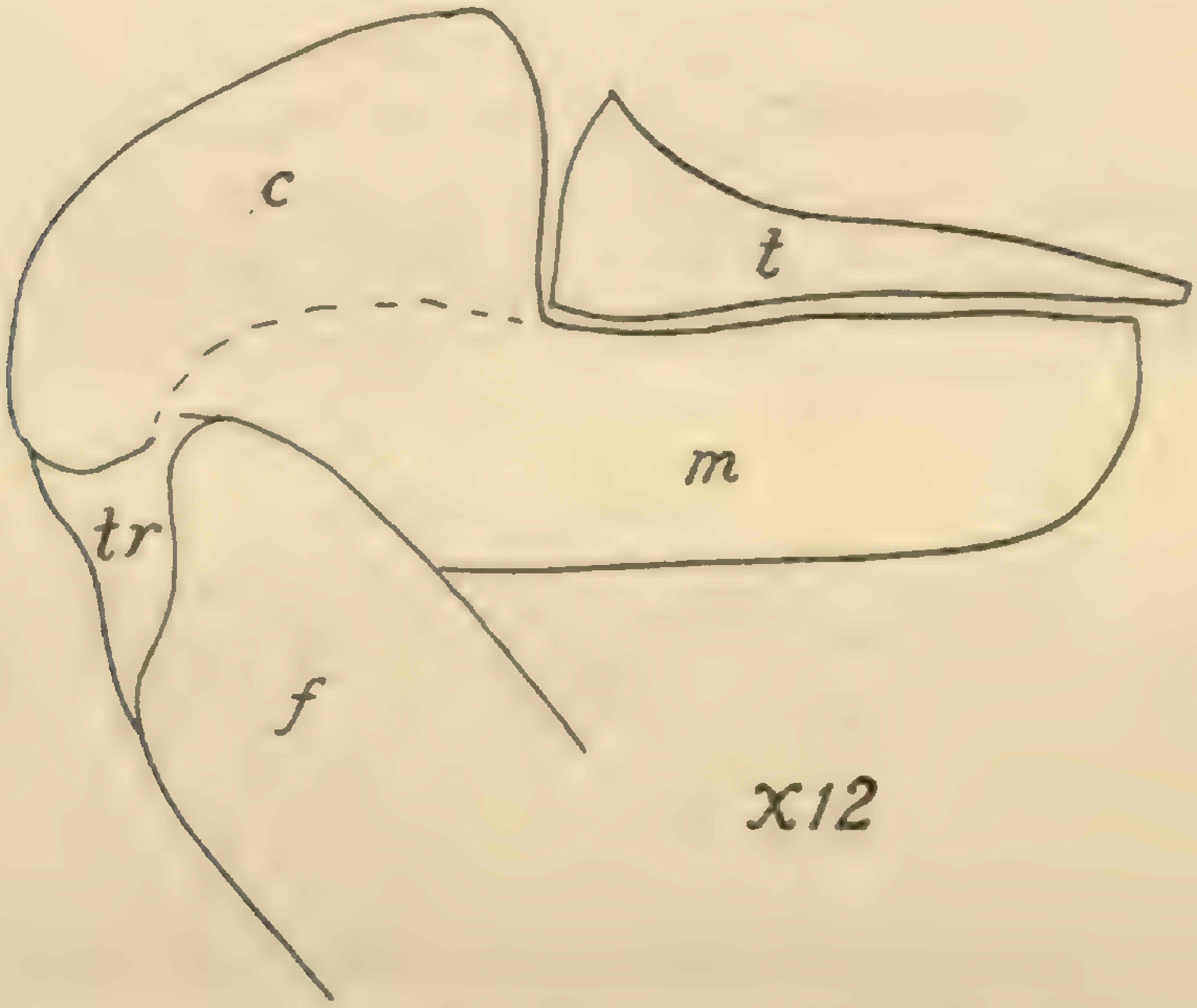


Fig. 2.—*Hydrophilus triangularis.* Mesothoracic coxa.

goridæ, Cixidæ, etc.) was the homologue of the coxopodite in Crustacea. In referring to Machilis, he has considered the trochantin of the prothoracic coxa as a primary segment, homologous with the coxopodite. From comparisons, however, with both Chilopoda and Diplopoda, we would regard the trochantin rather as a specialized character of the Hexapoda, which is absent in the Crustacea. Homologies based upon the form of the segment and manner of articulation certainly appear ques-

[1] Zur Morphologie der Gliedmassen und Mundtheile bei Crustaceen und Insecten. *Zool. Anz.*, pp. 193–198, 201–212, 1893.

[2] It seems probable that Hansen has here applied the name "trochantin" to the antecoxal piece and trochantin together.

tionable, since pronounced variations often occur within the limits of a single group.[1]

Until a closer relationship can be shown in the lines of descent of the two groups, Hexapoda and Crustacea, it would seem that an attempt to homologize the segments of the appendages would scarcely be justified. For the time being, we must assume that the segmentation of an appendage is a result brought about by certain indefinite factors, and that in these groups it does not necessarily imply a phylogenetic relationship.

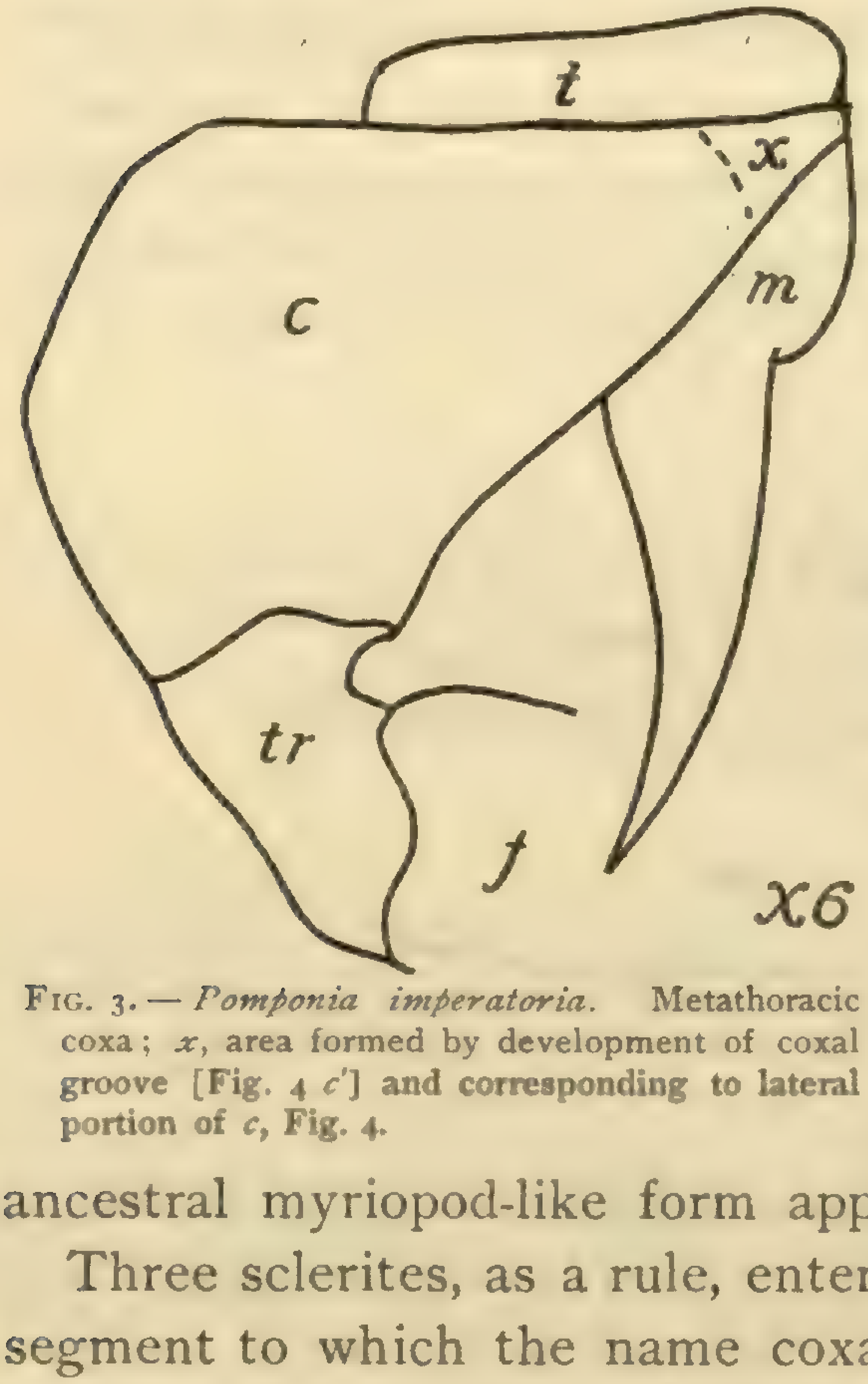


FIG. 3. — *Pomponia imperatoria.* Metathoracic coxa; *x*, area formed by development of coxal groove [Fig. 4 *c'*] and corresponding to lateral portion of *c*, Fig. 4.

That the trochanter of the Myriopoda and Hexapoda represents a distinct segment seems obvious, and that its fusion with the femur took place in some ancestral myriopod-like form appears probable.

Three sclerites, as a rule, enter into the composition of the segment to which the name coxa is given, *viz.*, *coxa genuina*, meron, and trochantin. Audouin[2] applied the name "trochantin"[3] to the lateral margin of the posterior coxa (meron) in *Dytiscus circumflexus*, erroneously believing it homologous with the trochantin on the anterior and mesal coxæ[4] of *Buprestis*

[1] Compare Arachnida, or, in Coleoptera, the metathoracic coxa of Dytiscus and Hydrophilus.

[2] Recherches anatomiques sur le thorax des animaux articules et celui des insectes hexapodes en particulier. *Ann. Sci. Nat.*, tome i, p. 125, 1824.

[3] This word had been previously used by Chaussier [Littré, *Dict. de Médecine*, p. 1632] during the latter part of the eighteenth century to designate a small process on the upper part of the femur in the human skeleton. From the note Audouin appends, he evidently felt some constraint in conforming to the custom of transferring such terms to invertebrate anatomy when no homologies could be demonstrated.

[4] In the metathorax of the Coleoptera the trochantin has been lost through specialization, although traces of it are noticeable among many forms (Hydrophilus, certain Cerambycidæ, etc.).

gigas, which he subsequently mentions.[1] Later, in his contribution to Cuvier's "Le Regne Animal," he figures the prothoracic trochantin of *Oryctes nasicornis*. The present confused terminology of these segments is due to the preceding error of Audouin. Newport[2] made a somewhat similar error by describing the anterior margin of the coxa (*coxa genuina*) in *Hydrous piceus*, as the metathoracic trochantin. Among the recent writers on insect anatomy, Packard[3] confuses the trochantin with the meron; Miall and Denny[5] hold that the occurrence of the joint applied to the coxa (trochantin) "is so partial" that it need scarcely be taken into consideration; Sharp[4] believes with Packard that the posterior part of the coxa (meron) in Panorpa represents the trochantin; while Comstock,[6] in a description of the metathorax in *Euchromia gigantea*, agrees essentially with the preceding, although he correctly figures the trochantin of the prothorax and mesothorax. Lowne[7] regards the piece

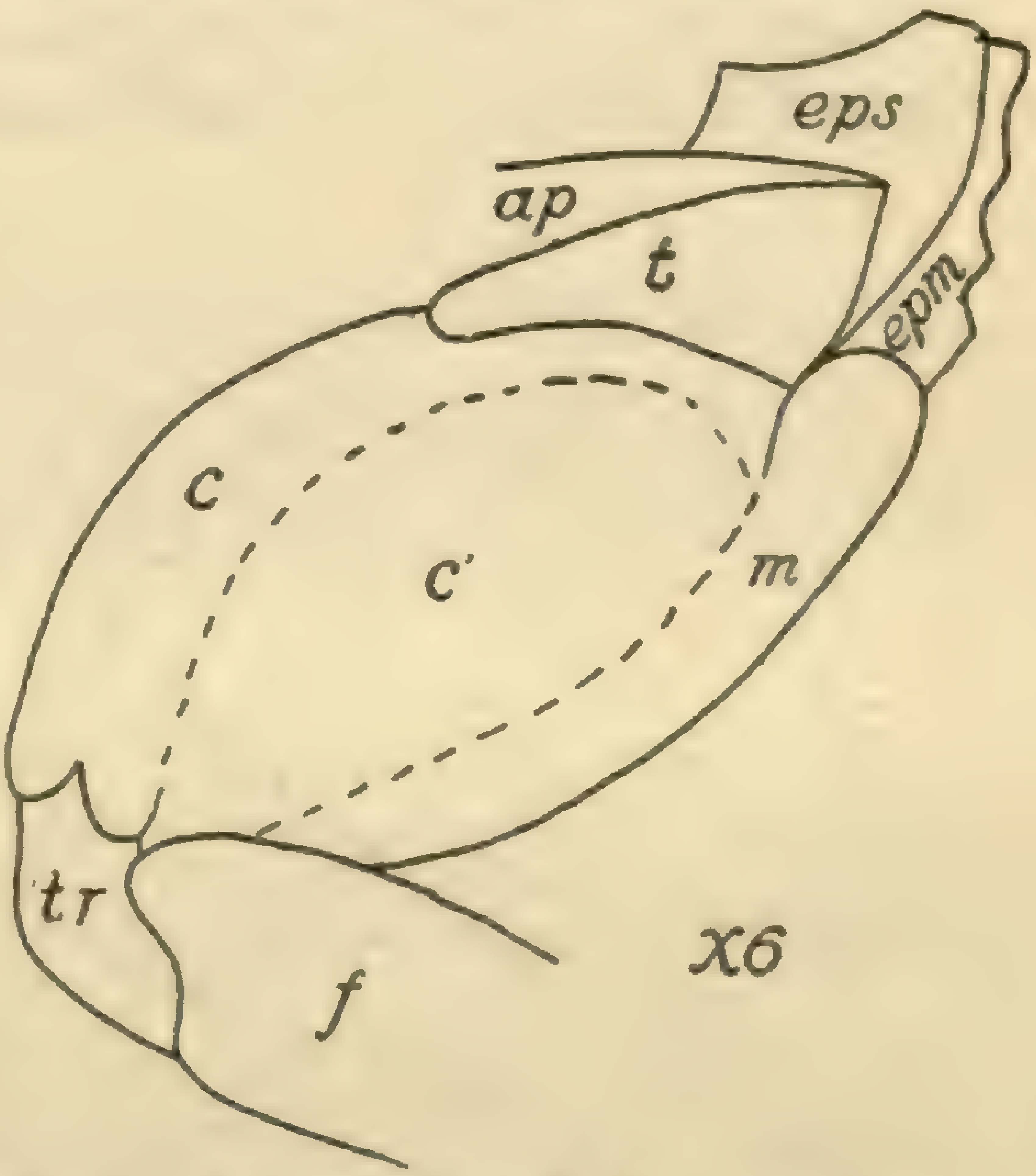


FIG. 4.—*Periplaneta orientalis*. Metathorax; *c'*, coxal groove formed for reception of femur.

[1] Étude de la poitrine ou des pattes inférieures et latérales du mesothorax. *Ann. Sci. Nat.*, tome i, p. 426, 1824. This is merely a continuation of Recherches anatomiques.

[2] Todd's *Cyclopedia of Anatomy and Physiology*, p. 916, 1835–59.

[3] Systematic Position of the Orthoptera in Relation to the Orders of Insects. *Third Report U. S. Ent. Com.*, 1880–82. *A Text-Book of Entomology*, p. 95, 1898.

[4] The Structure and Life History of the Cockroach, p. 61, 1886.

[5] *Camb. Nat. Hist.*, vol. v, p. 104, 1895.

[6] Manual for the Study of Insects, p. 504, 1895. It was due to Professor Comstock's suggestion of a possible error in considering the lateral margin of the metathoracic coxa of Euchromia as the actual homologue of the mesothoracic trochantin, that the study leading to this paper was commenced.

[7] The Anatomy, Physiology, Morphology, and Development of the Blow-Fly, vol. i, p. 179, 1890–92.

termed by him "epitrochlea"[1] as "certainly the trochantin of Audouin," ignoring his previous suggestion that one should adhere to the rule of priority. Several other writers, notably Latzel (Chilopoda), Comstock and Kellogg (Lepidoptera), and Kolbe (Lepidoptera, Trichoptera, and Panorpa), have mentioned the existence of an apparent suture in the coxa of certain groups under consideration, but without attempting to discuss its meaning.

Immediately in front of the metathoracic coxa, particularly among the Coleoptera, a small sclerite is discernible, which bears the name of antecoxal piece. This is also well shown in Cicada, some species of which (*Cicada dorsata*) possess a piece homologous with that found in the Coleoptera; while in others (*Cicada tibicen*),[2] instead of being chitinized, the part is often membranaceous in structure, and serves to retain the coxa more firmly in the coxal cavities, thus indicating its origin; and the presence of a homologous piece in the mesothorax of many Coleoptera (Passalus, etc.), occurring at the same time with the trochantin, proves that it is distinct from the latter.

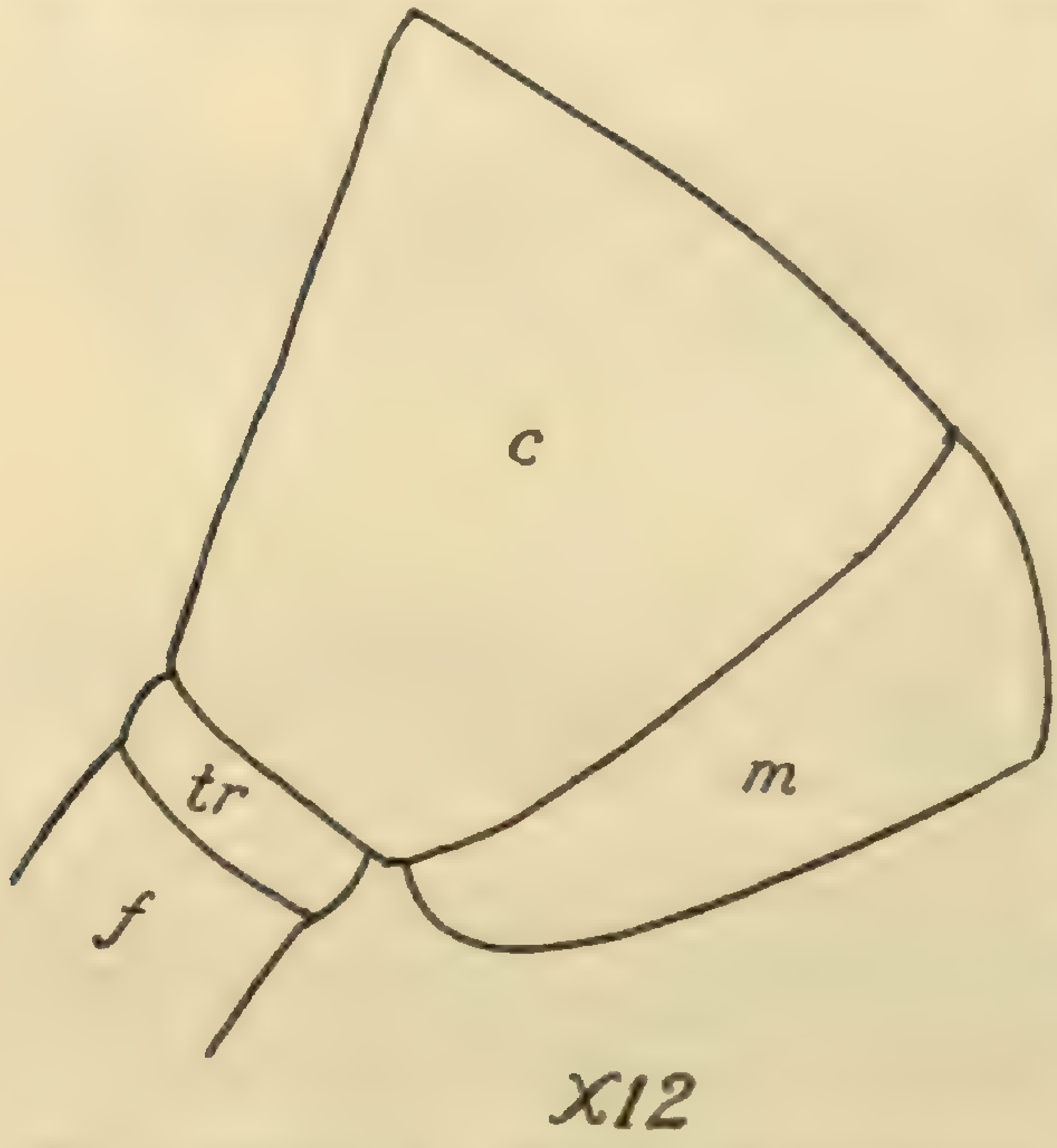


FIG. 5.—*Scutigera sp.* Coxa showing fusion of coxa genuina and meron.

The *origin* of the three pieces, *coxa genuina*, meron, and trochantin, the relative positions of which are shown in the accompanying figures, is more difficult of explanation. A striking characteristic of the Hexapoda and Chilopoda is the more or less complete fusion of the first two (*coxa genuina* and

[1] The homology of this with the trochantin appears doubtful.

[2] Although a good series was examined in which the other sclerites were well chitinized, the absence of chitinization in the antecoxal piece may be the result of immaturity. This, however, would not alter the conclusion.

meron) into the so-called coxa. Theoretically the episternum[1] and epimeron may be regarded as corresponding basal segments of these fused pieces, and taking into consideration the apparent absence of a piece homologous with the meron in the Diplopoda, we are led to the interesting inference that this group represents a class in which *each primitive metamere bears a pair of appendages*, while the Chilopoda and Hexapoda represent a widely divergent class, in which *two primitive metameres have attained a more complete fusion,*[2] *the rudimentary appendage belonging to each posterior segment fusing with the base of the functional appendage belonging to the anterior metamere.*[3] The posterior appendage would then be represented by the meron and epimeron.[4] In this case we can refer the origin of *coxa genuina* and episternum, as well as the meron and epimeron, to the same causes which produce segmentation in the appendage. The trochantin appears to be nothing more than a part of the antecoxal piece, a lateral prolongation of which became constricted off in a primitive form. Again we are confronted with the question as to the origin of the appendages in the Arthropoda, whether they are ventral or dorsal parapodia, or a fusion of the two, as in Nereis, or whether the

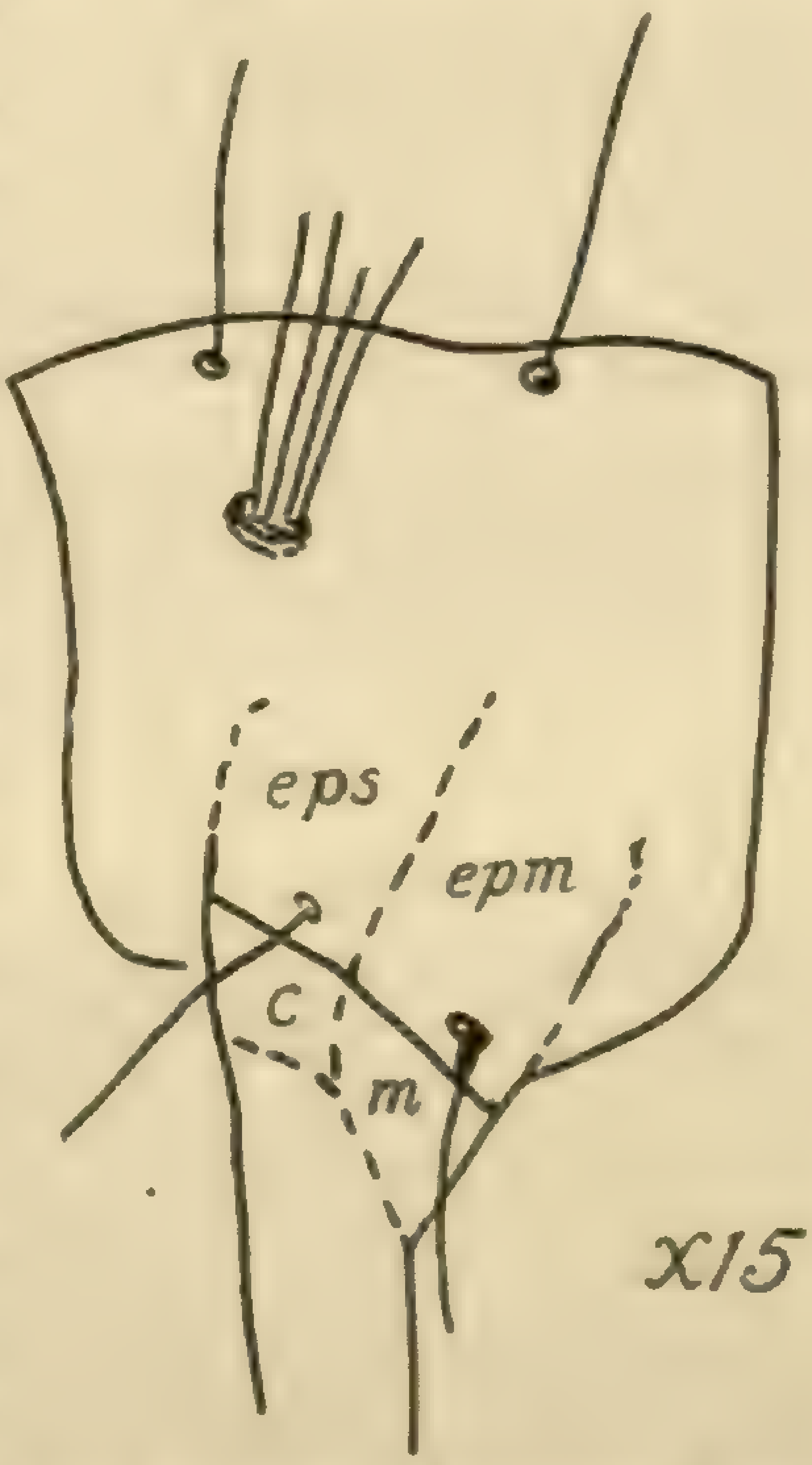


Fig. 6. — Larva of *Phryganea.* Mesothorax, showing early indications of coxa genuina and episternum fusing with meron and epimeron.

[1] Frequently the episternum appears to be cut off from the coxa by the sternum or by the trochantin, but in such cases the coxa is usually prolonged internally, so that it meets the episternum.

[2] At present there appears to be better evidence for believing that these pieces indicate a fusion of the segments than to hold that an exopodite and entopodite are represented.

[3] A study of the position and homologies of certain of the pleural and dorsal sclerites in Hexapoda and Chilopoda appears to confirm this inference.

[4] While thus far the majority of embryological evidence appears to be against this view, it seems possible that secondary modifications have caused a misinterpretation of the lines of descent.

origin was entirely independent of the parapodia. A study of Peripatus appears to throw no light on the subject under discussion, beyond indicating that in using the term "primitive metamere" we must not exclude the idea that such a metamere may in turn represent a fusion of an indefinite number of annuli. Evidence is thus added to a segment-fusion theory rather than to the biramose theory.

While it appears possible that the exopodite and entopodite in Crustacea may have developed from dorsal and ventral parapodia, in direct contrast to the manner indicated above for the Chilopoda and Hexapoda, further study may show a common origin of the two processes.

Summary.

In Hexapoda and Chilopoda the "coxa" is composed of two more or less fused segments, *coxa genuina* and meron.

The antecoxal piece results from the chitinization of the membrane connecting the coxa with the sternum.

The trochantin probably originated from a lateral portion of the same membrane.

Audouin erroneously homologized the lateral margin of the posterior coxa in *Dytiscus circumflexus* with the trochantin of the prothorax and mesothorax.

The trochanter represents a distinct segment of the legs.

The meron and *coxa genuina*, together with their corresponding basal segments epimeron and episternum, give evidence of a fusion between two primary metameres in the Hexapoda and Chilopoda.

In Hexapoda and Chilopoda the anterior metamere bears the functional, and the posterior, the rudimentary leg.

Of the primitive Hexapoda, Neuroptera [Planipennia] exhibit the most generalized condition in the development of the coxa, while in Thysanura and Orthoptera a high degree of specialization is shown.

Anatomical Laboratory, Brown University.
October 27, 1899.

NOTES ON THE PSYCHOLOGY OF FISHES.

R. W. SHUFELDT.

LAST year Dr. C. O. Whitman of the University of Chicago delivered a very able lecture on "Animal Behavior," it being one of the biological lectures from the Marine Biological Laboratory, Woods Holl, Mass.[1] In the leading paragraph Dr. Whitman very truly points out the fact that "animal behavior, long an attractive theme with students of natural history, has in recent times become the center of interest to investigators in the field of psychogenesis. The study of habits, instincts, and intelligence in the lower animals was not for a long time considered to have any fundamental relation to the study of man's mental development. Biologists were left to cultivate the field alone, and psychologists only recently discovered how vast and essential were the interests to which their science could lay claim" (p. 286). This is as true a statement as has been made in the premises in question in any connection, and the person who has paid any attention to psychological literature during the last ten years is well aware of the fact that in the discussions that have been going on there on the subject of instinct and intelligence, the psychologist has been compelled over and over again to draw upon the observations made by the biologist upon the habits and physiology of animals in order to lay down the very base for his theories in regard to the aforesaid faculties. Professor Whitman's recent researches have lent a powerful impulse to the interest taken in this subject, the more so from the fact that being a trained biologist himself, and possessed of a keen appreciation of the modern advances in psychology, he has been enabled to attack the question in the double capacity of naturalist and psychologist. So far as the writer's present information carries him, the researches of this observer have been chiefly devoted to the studying of the

[1] Boston, Ginn & Company, 1899.

habits and behavior of leeches (Clepsine), the large fresh-water amphibian Necturus, and to the various species of wild and domestic pigeons.

From these he draws very broad conclusions, so without entering upon a discussion of the theories touched upon in this meritorious memoir, for I have already done that elsewhere,[1] the present paper will take into consideration only such facts as concern the behavior of fishes. Moreover, what is here said will refer in particular but to the true bony fishes, or Teleostei, although, for aught that is known to the contrary, it is probably true of the entire group. Aside from some few well-known exceptions (Amblyopsis and congeners), that fishes possess excellent visual powers, even to the extent of keen discrimination between objects, there can scarcely be any manner of doubt. Therefore their appreciation of light and their sensitiveness to it follow as a natural consequence. Further, there is every reason to believe that fishes are so organized that they are extremely sensitive as to any disturbance of the element in which they live, when such disturbance is made within the range of the power of their nervous organization to appreciate it. Whether any fish is as sensitive in this respect as a leech (Clepsine) I think is an open question, for, as Whitman has shown, we have but to touch with extreme care with a point of a fine needle the surface of the water over a leech, when the latter is in a dish containing it, to see the animal suspend the act of respiration, *slightly* expand its body, and hug closer to the glass or china dish wherein it has been placed. This experiment must be performed with great caution, for any undue disturbance will effectually defeat the looked-for result. The very extreme sensitiveness of the creature is absolutely remarkable.

Coming now to the sensitiveness of fishes, I take occasion to quote in full a note that Professor Eigenmann furnished Dr. Whitman with for use in his paper on "Animal Behavior"; it runs as follows: "*Chologaster papilliiferus*, a relative of the blindfishes living in springs, detects its prey by its tactile organs, not by its eyes. A crustacean may be crawling in

[1] R. W. Shufeldt, M. D. Animal Behavior. *Popular Science*, vol. xxxiv, No. 3, pp. 45, 46. New York, N.Y., March, 1900.

plain view without exciting any interest, unless it comes in close proximity to the head of the fish, when it is located with precision and secured. The action is a very strong contrast to that of a sunfish, which depends on its eyes to locate its prey. A Gammarus seen swimming rapidly through the water and approaching a Chologaster from behind and below was captured by an instantaneous movement of the Chologaster, when it came in contact with its head. The motion brought the head of the Chologaster in contact with the stem of a leaf, and

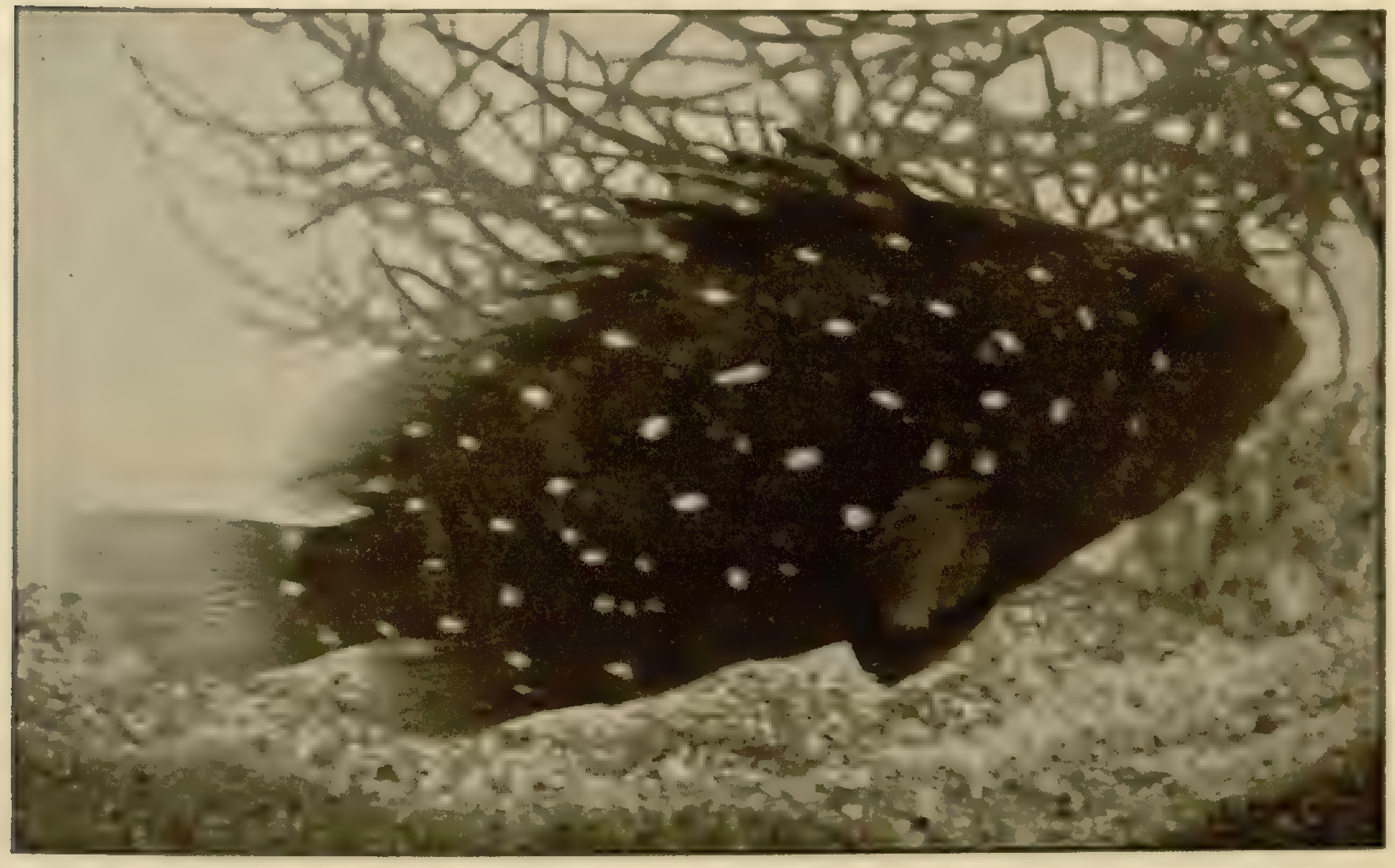


FIG. 1. — The Snowy Grouper (*Epinephelus niveatus*), juv. Photographed from life by R. W. Shufeldt.

instantly it tried to capture this also. Since the aquarium was well lighted, the leaf in plain sight, it must have been seen and avoided if the sense of sight, and not that of touch, were depended upon.

"In Amblyopsis, the largest of the blindfishes of the American caves, the batteries of tactile organs form ridges projecting beyond the general surface of the skin. Its prey, since it lives in the dark and its eyes are mere vestiges, is located entirely by its tactile organs. This is done with as great accuracy as could be done with the best of eyes in the light, but only when the prey is in close proximity to the head. Coarser vibrations in

the water are not perceived or are ignored, and apparently stationary objects are not perceived when the fish approaches them. If a rod is held in the hand, the fish always perceives it when within about half an inch of it, and backs water with its pectorals. If the head of a fish is approached with a rod, the direction from whence it comes is always perceived and the correct motion made to avoid it. This reaction is much more intense in the more active young than in the adult. One young about 10 mm. long determined with as great precision the direction from which a needle was coming as any fish with perfect eyes could possibly have done. It reacted properly to avoid the needle, and this without getting excited about it."

That fishes with perfect eyes depend entirely upon them in the detection and capture of their prey is easily proved by the difference in their behavior when feeding in perfectly clear or in muddy water. This experiment can be made in a large aquarium containing a number of hungry black bass, and turning a few small yellow perch loose among them. If the water be clear, short work is made of the victims, but their capture is made less and less certain the muddier the water happens to be. It is more than likely that some of the semi-blind deep-sea fishes, as, for example, *Mancalias shufeldtii*, are quite as sensitive to disturbances of a very delicate nature of the water in their immediate neighborhood as is Amblyopsis of the Mammoth Cave of Kentucky. On the other hand, the eyes of some of these fishes have come to be of enormous size in proportion to the size of their owners, and this to gain all the available light possible. Consequently, there is probably a compensating distinction in this regard among such fish as I have here noticed; in other words, the more perfect the sight the less need of a highly organized sensitive apparatus and *vice versa*.

But now comes another question in the behavior and psychology of fishes that will require a far greater knowledge on our part of the habits and history of these vertebrates, before biologists will arrive at anything like a unanimity of opinion regarding the matter, or the observations in the premises, and the observed facts are sufficiently numerous to insure the solution of the entire problem. It involves the whole question of

instinct and intelligence and some of the knottiest points in the entire range of biology. It has been observed in fishes that many of them have the habit of "pausing before the bait" prior to making a seizure with the jaws. This, according to Whitman, has its origin in *fear*, and he studied quite closely the corresponding, though somewhat different series of acts in Necturus. It is an *instinctive* timidity rather than a strategic approach of the fish not to alarm its prey and thus defeat capture. The long and careful series of experiments made by Professor Whitman in the case of numerous specimens of Necturus, both young and old, seem to prove very conclusively that their intensely shy behavior, when approaching their prey or food, is due to an innate timidity or really fear.

Young sunfishes (Lepomis) I have studied for many years at different times and places in aquaria, and I have observed the habit in the young of that species of "pausing before the bait," or really their food, prior to taking it. The same behavior obtains in the adult sunfishes, but in them it can be overcome by education to a large extent, for I have seen them *immediately* attack in numbers one's finger when placed in the water of the aquarium containing them; whereas, when the experiment was first tried, they evidently all stood in great fear of the object, however gently it was placed in the water. A study of the young and old of Chætodon in this connection and the method of some of the species of that genus of taking their prey would be interesting.

In speaking of the marked timidity of Necturus in the taking of its food or seizing its prey, Professor Whitman says: "If this series of acts represents an organic sequence, and if the behavior as a whole takes the form determined by the organization, as seems to me beyond reasonable doubt, we have an instinct the history of which may be coextensive with the evolution of the animal. We stand at the end of an interminable vista. The specific peculiarities of organization in Necturus form but an infinitesimal element of the problem. Scarcely a feature of the instinct belongs exclusively to Necturus. It is at least widely diffused among vertebrates, especially among fishes. The differences in the manner of execution among dif-

ferent forms, so far as I have observed, are of quite a superficial nature. The instinct evidently has its root in the general instinct of preying, which is doubtless coeval with animal organization" (p. 307).

In the adults of some species of fish it is very evident, in the matter of seizing their prey, that the elements of both *hesitation* and fear are entirely absent, as witness the bold rush of the pike to capture a minnow, or the manner in which a trout or a salmon instantly takes the *artificial fly*. Hundreds of similar cases could easily be cited.

This autumn the writer has been making photographs of living rare fishes at the building of the U. S. Fish Commission at Washington, D. C., and among them were some beautiful specimens of the young of the Snowy Grouper (*Epinephelus nivecatus*) (see figure 1) and the Big-eye (*Pseudopriacanthus altus*). Both of these species exhibit a most remarkable behavior under certain conditions. The Snowy Grouper, for instance, when overteased in any way, or sometimes without even that provocation, or when its food is presented to it, whether the act be voluntary or involuntary, passes through a peculiar fit or spasm, simulating all the symptoms of a dying fish. Not only this, but the specimen so behaving *changes in color* from the normal brownish-black to a pale leaden hue, and as the spasmodic stage of the attack subsides, the fish comes to lie perfectly motionless upon its side, or else floats on the bottom, belly upwards. It will remain in this condition for nearly half an hour, when signs of animation again make their appearance, and the individual gradually assumes its former normal condition and color. The Big-eye is another species exhibiting somewhat similar attacks under nearly like conditions, but this species, I am told, sometimes dies in one of its more violent spasms. It is a well-known fact that some species of large fishes that prey upon smaller species will not devour them unless captured when making an exciting attempt to escape and in full vigor of health. They will not touch a dead specimen, or even one in the act of dying. I have noticed this especially in the case of pickerel. Now this peculiar fit that seizes the young of the Snowy Grouper may be due to the result of an acute reaction caused by fear; but, on the

other hand, it may be something of the nature of "feigning death," and thus be useful to the form in nature. Possibly there may be some large form in the seas that preys upon young Snowy Groupers, and *prefers* to take them only in the excitement of actual chase, and ignores a dead or dying one. If this chance to be true, these peculiar "fits" of Epinephelus and Pseudopriacanthus are in favor of the preservation of the species. Indeed, we are hardly yet upon the threshold of our knowledge of the habits and *behavior* of fishes in nature, much less are we enabled to solve the problem in an untold number of cases, how in any special instance any special act in a fish's behavior first arose, and whether that act is wholly or only in part prompted by instinct. Whitman's "Animal Behavior" and similar memoirs will in the future have a beneficial result in stimulating investigation and research in such directions.

A NEW MUSEUM TABLET.

FRANK C. BAKER.

For the past five years the writer has been experimenting upon a durable and convenient museum tablet, which would remain perfectly flat when the label and specimens were attached, and which would give the largest amount of exhibition room with a minimum of label area. Such a tablet has been worked out by the writer and a short description of it may be of interest to those having the same problem to meet. I might say, however, that the idea was first conceived while examining the tablets in the American Museum of Natural History, New York, upon which are mounted Hall's types of fossils.

The foundation is No. 20 binder's board, which has been found quite heavy enough for all practical purposes. About the edge of this is bound black gummed paper, similar to that used for binding lantern slides. The center for the specimens and label is next prepared, and for this the writer has selected a grade of manilla cardboard identical with that used for herbarium genus covers ; this is of a rich cream color and does not fade when exposed to the light, and presents a surface admirably setting off the black, full-faced type used. At a first glance a finished tablet appears as though made of ivory. This board is cut just enough smaller than the tablet to allow a black border of an eighth of an inch. For very light specimens a black center is used, cut just small enough to allow an eighth of an inch of light margin between it and the black border of the tablet, and also to leave room for the label which is generally 3 × 1 inch.

In securing a good black the writer was compelled to resort to a thin black paper used by paper-box manufacturers, as no printer seemed able to print a uniform black, the first ones printed being gummy, and the last shading into a gray. The

black center is first pasted upon a manilla board with *good library* paste, and then the board is attached to the tablet by simply gumming the *edges* with a thin solution of Le Page's glue poisoned with corrosive sublimate to keep insects away. At this point the tablet must be placed under a press to dry, in order to avoid warping. The writer has used thin sheets of lead for this purpose, which have been very successful.

After drying for three or four hours the tablet is ready for the labels and specimens; the former being printed upon the same stock as the tablet cover, and attached by putting a few drops of glue upon the ends and in the middle, and placed under a press for an hour or so. For order, class, family, etc., a tablet 3×1 inch has been adopted and the printed label glued to it. For genera a tablet $3 \times \frac{1}{2}$ inch has been found desirable. The tablets have been graded in the following sizes, the unit width being three inches: 3×2, 3×4, 3×6, 3×9, 6×6, 9×9. These sizes will accommodate any specimens save those which should be placed in special upright cases. The larger tablets, 6×6 and 9×9, will need to have a piece of heavy paper pasted on the reverse side, to keep them from warping. The specimens are attached to the tablets with Le Page's glue.

The expense of these tablets will not exceed one and a half cents each, and several hundred can be manufactured in a day. A case installed in this manner presents a handsome appearance and greatly increases the facility for examination.

It has been urged by some that the tray is better adapted to museum purposes than the tablet, on account of the danger of mixing species. In answer to this the writer would say that the collections of the Chicago Academy of Sciences have been mounted upon tablets for the past six years, and up to the present time no mixing has taken place. Of course care must be used, with the tray equally as with the tablets, to guard against accidents. The new tablet spoken of above has been in use in the institution mentioned for the past five months.

THE LOWER AND MIDDLE SONORAN ZONES IN ARIZONA AND NEW MEXICO.

T. D. A. COCKERELL.

For some years it has been a matter of controversy whether the Mesilla Valley (3800 ft. altitude) in New Mexico should be regarded as Lower Sonoran. The present writer classed it as Upper Sonoran, and later placed it in an intermediate zone, which he proposed to call Middle Sonoran. Dr. C. H. Merriam, on the other hand, regarded it as true Lower Sonoran, and so mapped it.

The writer, unfortunately, had never been able to study the true Lower Sonoran until his visit to Phœnix last year. This visit, while undertaken for other purposes, enabled him to reach some new conclusions, which are here set forth. While the discussion is largely technical, it is hoped that it will arouse some general interest, as the conclusions reached are of practical as well as theoretical interest.

We have in New Mexico and Arizona a number of fertile valleys, of which the Salt River and Mesilla Valleys are perhaps the most important. The Salt River Valley, in particular, is said to export more fruit than all the rest of Arizona combined. Now these valleys, between them, have to supply certain markets, and it is of the highest importance to each one that it should produce that which grows to a reasonable degree of perfection and finds a ready sale. If the valleys all belong in the same zone, they may be expected, speaking broadly, to produce the same crops, and it may be that in so doing they will overstock the market. But if there is in reality a great diversity in the agricultural conditions of the several valleys, so that they not only differ in detail but belong to different life zones, — this is a fact of the utmost practical importance, since it indicates that there may be such diversity in products as almost to avoid injurious competition. More-

over, if this diversity exists, it is of great value to the ranchman or orchardist to be made aware of it, since he will not then waste time and money by setting out plants which cannot be expected to succeed.

As a matter of fact, such problems as these have already been largely solved in the cultivated areas, by the experience — often tedious and expensive — of the residents. But they have not been solved for the areas which may yet be brought under cultivation, nor are the facts sufficiently accessible to residents in other states who expect to locate in the arid west. Yet again, even those residents who are satisfied with what their own locality will produce, are usually not acquainted with the possibilities of other districts, possibilities which affect them in so far as they affect the markets.

Last spring the writer had the pleasure of meeting Dr. Merriam at Washington, and at his suggestion made for him a list of the commoner trees and shrubs of the Mesilla Valley. Dr. Merriam, glancing over this, at once said : "With possibly one or two exceptions, these are *all* Lower Sonoran types." My investigations in the Salt River Valley have convinced me of the justice of this statement, and it may be said at once that, so far as the native flora is concerned, the Mesilla and Salt River Valleys may very well be placed in the same zone. The illustrative data given further on suggest more precisely the actual condition of affairs. Many of the plants which are abundant and conspicuous in the landscape are entirely the same, while others are so similar that they may be held to indicate rather the fact that we are three hundred and odd miles to the west of the New Mexico Valley than in a different life zone. In the list of insects common to the two valleys, also, we find many of the characteristic Mesilla Valley types, described as new from thence in recent years. The absolute differences, discussed under headings 3 to 5, are important in their way, and doubtless will be emphasized by further research ; but it is at least questionable whether they indicate a different life zone, or, rather, whether they would indicate one if no other facts supported the division.

Turning now to the cultivated products, the conditions are

entirely different. The contrast, instead of being weak, is of the strongest possible kind; and if the valleys compared are not in different zones, then life zones have no meaning for the horticulturist. We thus arrive at this conclusion:

In the arid west the influences of temperature upon the cultivated, irrigated plants, derived from moister regions, are very much greater than upon the native plants or animals, which have become so adapted that they endure without harm enormous variations of heat and cold.

Hence it results that from the horticulturist's standpoint, the Middle Sonoran zone is a very real division, and belongs rather with the Upper than the Lower Sonoran. We may almost define the Middle Sonoran as a zone having the cultivated products of the Upper Sonoran and the native products of the Lower.

It will of course be understood that the data here given are only illustrative, and the time is not ripe for statistical tables. It will be a matter for future research to determine the exact details of the differences between the two zones. It is reasonably to be expected, however, that we may by patient study find native species of plants and insects which afford reasonably close indications of the horticultural zones, and thus enable us to decide the zonal position in advance of cultivation. Such decisions will be greatly assisted when we are in possession of more precise meteorological data, but unfortunately we know too little at present about the daily variations of temperature in the several localities where weather observations have been made, and the differences between the temperatures of adjacent localities.

Although Tucson is considerably higher than Phœnix, it is undoubtedly Lower, as distinguished from Middle, Sonoran. Oleanders, olives, Washingtonia and date palms, pepper trees, and a cultivated Parkinsonia were seen there; and Professor Toumey tells me there is a "hot pocket" some fourteen miles to the east, where orange trees are growing.

One circumstance which artificially emphasizes the horticultural distinction between the Mesilla and Salt River Valleys is, that in the latter it is possible to irrigate the higher levels at the side of the valley, while in the former only the bottom

CULTIVATED PLANTS OF SALT RIVER VALLEY AND THE MESILLA VALLEY.

PLANT.	SALT RIVER VALLEY. (Minimum winter temperature, 32.2° F.[1])	MESILLA VALLEY. (Minimum winter temperature, 9° F.)
Date palm.	Does well.	Cannot stand the winter cold.
Washingtonia palm.	ditto.	ditto.
Olive.	ditto.	ditto.
Orange.	Does well at the sides of the valley.	ditto.
Almond.	Will bear a good crop if protected by smudges.	Cannot escape the frost in spring.
Peach.	Does well.	Does well.
Pear.	ditto.	ditto.
Apple.	Climate too hot and dry in summer.	ditto.
Fig.	Tree grows well without protection, but not successful as a crop on account of the dryness.	Killed to the ground in exposed places; grows well and fruits abundantly when protected by four walls.
Pomegranate.	Does well; much used for hedges.	Small plants growing in protected situations.
Grape.	Raisin and wine grapes do well.	Wine grapes do well.
Oleander.	Does well.	Winter too cold.
Pepper tree (*Schinus*).	ditto.	Not tried; winter doubtless too cold.
Sorghum.	ditto.	Does well.
Alfalfa.	Does well, but summers rather too hot and dry.	Grows to perfection.
Sugar beet.	Can be grown in the cool part of the year, Feb.–May.	Summers probably too hot for best results; Feb.–May too cold.
Irish potato.	Can be grown fairly well from Feb.–May.	Summers too hot; Feb.–May too cold.

lands are under ditch. In the cold weather the cold air settles in the lower lands, leaving the sides of the valley relatively warm, and hence it is that oranges can be cultivated with great success in the region about Ingleside, while they do not suc-

[1] From the observations made by Mr. W. G. Burns of the Weather Bureau at Phœnix it appears that the lowest temperature at that place in January, 1900, was 34° F., but on Feb. 7, 1899, the mercury fell as low as 24° F.

ceed commercially at Phœnix. The Larrea in the Mesilla Valley occupies only the higher levels, its lower limit, a little distance from the valley bottom, being as clean-cut as if it had been planted. But in the Salt River Valley the Larrea covers the whole area, and grows to a great size in the bottom lands, which are never so cold as to injure it. It is the desert land, once occupied by the Larrea, which has under irrigation been converted into the most flourishing orchards; and could the Larrea land of the Mesilla Valley be irrigated the results would doubtless be most gratifying.

These examples show us the value, on the one hand, of an exact knowledge of temperature conditions; and the fallacy, on the other, of mapping the temperature for the entire country from the observations made in a few widely scattered localities. Thus the temperature tables for Phœnix would not apply to Ingleside, nor those for Mesilla Park to the bench a couple of miles away. The writer has discussed the subject from his own standpoint, that of the fauna and flora; but he would not be understood to undervalue in any degree the knowledge of temperature in mapping life zones; all he would urge is, that for the proper mapping of zones on the temperature basis, we need a mass of information we do not possess, and are not likely to possess in the near future.

Representative Facts Regarding the Native Fauna and Flora.

(*1*) *Species Common to the Mesilla Valley and Salt River Valley.*

Plants.

Perezia nana Gray.	*Larrea tridentata* DC.
Pluchea (*Tessaria*) *borealis* Gray.	*Cladothrix lanuginosa* Nutt.
Pectis papposa Harv, and Gray.	*Hoffmanseggia stricta* Benth.
Aster spinosus Benth.	*Populus fremonti* Wats.
Helianthus annuus L.	*Salix fluviatilis* Nutt.
Baccharis glutinosa Pers.	*Atriplex canescens* (Pursh) James.
Verbesina encelioides (Cav.) Gray.	*Datura meteloides* DC.

No attempt was made to catalogue the flora. The plants above cited are merely some of those which are so abundant and conspicuous as to give a character to the landscape.

Besides the identical species of Baccharis and Atriplex, the Salt River Valley has another Baccharis and two other species of shrubby Atriplex not found in the Mesilla Valley.

It seemed to me that the cottonwoods (*Populus fremonti*) of the Salt River Valley were not perfectly identical with those of the Mesilla Valley, but the species is presumed to be the same.

Insects.

Colias eurytheme Boisd.
Pyrameis cardui (L.).
Lycæna exilis Boisd.
Libythea bachmani carinenta (Cram.).
Synchloë lacinia Geyer (larvæ on Xanthium and sunflower).
Heliothis armiger Hubn. (Buckeye).
Asphondylia neomexicana (Ckll.).
A. atriplicis (Towns).*
Diplosis atriplicicola Ckll.*
Chilocorus cacti (L.).
Drosophila ampelophila Loew.
Dorymyrmex pyramicus Rog. (Buckeye).
Hesperotettix viridis (Thos.).
Sphærophthalma donæ-anæ Ckll. and Fox.*
S. foxi Ckll.
Coleophora suædicola Ckll. (Tempe).*
Eromene (*Euchromius*) *ocellea* (Haw.) Zell. (Buckeye).
Megilla maculata (De Geer).
Aphalara suædæ, Schwarz. MS. (Tempe).
Allorhina mutabilis Gory.
Microcentrum retinervis Burm.
Dicraneura cockerelli Gill.*
Stictocephala festina Say.
Eriococcus tinsleyi Ckll. (leaf-form).*
Phenacoccus helianthi Ckll.*
Calliopsis coloradensis coloratipes (Ckll.).
Perdita asteris Ckll.*
P. salicis Ckll.
Exomalopsis solani Ckll. (Tempe).*
Agapostemon melliventris Cress. (Tempe).
Halictus pseudotegularis Ckll.
H. meliloti Ckll.*
Prosapis mesillæ Ckll. *
Mellisodes agilis Cress.
Cockerellia albipennis helianthi (Ckll.).*
Aspidiotus juglans-regiæ albus Ckll.*
Hormilia elegans Scudder.*

The species and varieties marked with an asterisk were originally described from Mesilla Valley specimens.

I have included some species found at Buckeye, as, although this is not actually in the Salt River Valley, it is virtually part of the same region.

(2) *Representative Species similar to, but not identical with, those of the Mesilla Valley.*

Plants.

Sphæralcea variabilis n. sp. — The common perennial Sphæralcea of the Salt River Valley, which at first sight might be taken for *S. lobata* Wooton, equally common in the Mesilla Valley. The leaves vary from 1¼ to over 3 inches long, and resemble in shape those of lobata, being quite long, with obtuse lateral lobes; but they average broader, are somewhat more regularly and finely crenulate, or the margins almost entire, and the living leaves have the surface, and especially the margins, much more wrinkled. The difference between the plants, as seen living, is sufficient to strike the eye, but it is a difference in average rather than absolute characters. There is, however, one character of greater value; the carpels of lobata are conspicuously cuspidate, whereas in variabilis they are rounded at the top, and bear no cusps. It may therefore be said that variabilis resembles lobata in its leaves, but angustifolia rather in its fruit. The basal portion of the carpels is very strongly reticulated, as in lobata. The flowers are as in lobata. This plant is here called a species, being about as distinct as the other members of its series — angustifolia, lobata, and fendleri; but it would be possible to regard variabilis as a race of lobata, or both as races of fendleri.

S. variabilis was found freely blooming about Phœnix in October. It is not so tall a plant, on the average, as *S. lobata.*

Isocoma acradenia (Greene) Greene. — This is the common Bigelovia of the vicinity of Phœnix, exactly occupying the place taken in the Mesilla Valley by *I. heterophylla wrightii.* I had confused the Phœnix plant with *I. hartwegi*, but I found the real hartwegi (certified as such by Dr. Greene) abundant at Tucson, taking the place of acradenia. *I. acradenia* has the flowers of hartwegi, with the foliage (only smaller) of heterophylla wrightii.

Cucurbita palmata Watson. — Common in the Salt River Valley, taking the place of the Mesilla Valley *C. fœtidissima.*

Prosopis velutina Wooton. — The mesquite of Arizona, found at Phœnix, Mesa, Buckeye, Tucson, etc., is distinct from *P. glandulosa* Torrey, the mesquite of the Mesilla Valley.

Acacia greggii Gray. — Abundant in the Salt River Valley; much larger than the species of the Mesilla Valley.

Echinocactus lecontei (Engelm.) Toumey. — This barrel cactus takes the place of the Mesilla Valley *E. wislizeni* Engelm.; the latter, however, occurs at Tucson. *E. lecontei* is usually considered a variety of *E. wislizeni*, but when I saw it, it seemed to me distinct, and Professor Toumey tells me that it is a valid species.

Kallstrœmia grandiflora Torrey. — Very abundant in Phœnix; a very beautiful flower, which ought to be in cultivation. It is allied to the much less conspicuous *K. brachystylis* Vail. of the Mesilla Valley.

K. grandiflora arizonica Ckll., with much smaller flowers and much shorter flower stalks, is also common at Phœnix.

K. californica (Wats.) Vail. det. Wooton, was found near Buckeye. It has never been seen in the Mesilla Valley.

Croton sp. — The common Croton of the Mesilla Valley is *C. neomexicanus.* At Phœnix I found in its stead a tall species closely allied to *C. texensis*, but less leafy at the top, and with very much denser pubescence on the leaves. No description has been found to fit it, and it may be undescribed.

Lycium gracilipes Gray. — Abundant in the Salt River Valley, taking the place of the Mesilla Valley *L. torreyi.*

Insects.

Sphærophthalma gloriosa (Sauss.) takes the place in the Salt River Valley of *S. pseudopappus* in the Mesilla Valley. This is a so-called "velvet-ant," covered with long white hairs.

(3) Species entirely different from those of the Mesilla Valley.

Plants.

Cereus giganteus Engelm. — The giant cactus.

Holacantha emoryi Gray. — The crown of thorns.

Parkinsonia torreyana Wats. and *P. microphylla* Torrey. — The two species of palo verde.

Hetherotheca subaxillaris (Lam.) B. and R. — A yellow flowered composite, very abundant throughout the Salt River Valley. It is doubtless native, as I found two new bees (*Perdita mellina* Ckll. and *P. heterothecæ* Ckll.) specially attached to it.

The above are conspicuous in the landscape; no attempt was made to catalogue the less conspicuous forms.

Scale Insects.

It is an interesting fact that allied or identical plants in the two regions under consideration are in certain cases infested by entirely different scale-insects. Thus:

The Larrea in the Salt River Valley is infested by *Dactylopius irishi* Ckll. and *Tachardia larreæ* Comst., while the same plant in the Mesilla Valley produces *Dactylopius steelii* Ckll. and Towns., *Icerya rileyi* Ckll. and *Eriococcus larreæ* Parrott and Ckll.

The mesquite (*Prosopis velutina*) in the Salt River Valley is infested by *Xerophilaspis prosopidis* Ckll. and *Diaspis arizonicus* Ckll.; at

Tucson it produces *Aspidiotus candidulus* Ckll., *Toumeyella mirabilis* Ckll., *Eriococcus quercus toumeyi* Ckll. and the Xerophilaspsis. The mesquite (*Prosopis glandulosa*) of the Mesilla Valley produces *Icerya rileyi* Ckll. and *Dactylopius prosopidis* Ckll. The mesquite (*Prosopis juliflora*) of Jamaica produces *Icerya rosæ* R. and H. and *Dactylopius virgatus* Ckll.

(*4*) *Species of the Mesilla Valley absent from the Salt River Valley.*

A curious case is that of the mistletoe of the cottonwood, *Phoradendron macrophyllum* (*Phoradendron flavescens* var. *macrophyllum* Engelm., *Bot. Wheeler Surv.*, p. 252) which is abundant and destructive on the *Populus fremonti* of the Mesilla Valley, but does not go up the valley of the Rio Grande as far as its host, or down into the Salt River Valley, where the same cottonwood abounds. It is not that it is absent from the Gila basin, for it was first described from the Gila and Bonita Rivers. Its absence from the Salt River Valley is confirmed by Professor McClatchie; and, indeed, were it present it could not escape observation.

The bag-worm (*Oiketicus townsendi*) of the Mesilla Valley, although common at Tucson, was not observed in Salt River Valley.

(*5*) *Ants of Buckeye and the Mesilla Valley.*

A series of ants collected at Buckeye was kindly determined for me by Mr. Ernest André, and it appears that the ant-fauna of this region has little in common with that of the Mesilla Valley, as witness the accompanying lists :

MESILLA VALLEY.

Camponotus maculatus maccooki Forel.
C. marginatus decipiens Emery.
Formica subsericea subpolita Mayr.
Forelius maccooki Forel.
Lasius umbratus bicornis Foerst.
Dorymyrmex pyramicus Rog.
Aphænogaster albisetosa Mayr.
A. cockerelli André.
Tapinoma anale André.
T. sessile Say.
Atta (*Trachymyrmex*) n. sp.?
Pogonomyrmex barbatus Sm. (race *fuscatus*).
P. badius Latr.
P. californicus Buckl.
Monomorium minutum Mayr.
M. pharaonis L.
Pheidole morrisi Forel.
Solenopsis geminata Fabr.
Cremastogaster læviuscula clara Mayr.
Labidus harrisii (Hald.).

BUCKEYE.

Atta versicolor Perg.
Cremastogaster atra Mayr.
Aphænogaster pergandei Mayr.
Dorymyrmex pyramicus Rog.
Prenolepis vividula guatemalensis Forel.

SYNOPSES OF NORTH-AMERICAN INVERTEBRATES. VIII.

THE ISOPODA. — PART II.

ASELLOTA, ONISCOIDEA, EPICARIDEA.

HARRIET RICHARDSON.

IN addition to the references to the literature already given in Part I of the Synopsis of the Isopoda is the following list of papers pertaining especially to the fresh-water forms.

1871. PACKARD, A. S. The Mammoth Cave and its Inhabitants. *Amer. Nat.* Vol. v, p. 751.

1874. SMITH, S. I. The Crustacea of the Fresh Waters of the United States. *Rept. U. S. Fish Comm. for 1872–1873.* Pp. 657–661.

1876. FORBES, S. A. List of Illinois Crustacea, with Descriptions of New Species. *Bull. Ill. State Lab.* N. H., No. 1, pp. 8–13.

1876. HARGER, OSCAR. Description of Mancasellus brachyurus, a New Fresh-Water Isopod. *Amer. Journ. Sci.* (3). Vol. xi, pp. 304, 305.

1881. PACKARD, A. S., and COPE, E. D. The Fauna of Nickajack Cave. *Amer. Nat.* Vol. xv, pp. 879–880.

1890. GARMAN, H. A New Fresh-Water Crustacean. *Bull. Essex Institute.* Vol. xxii, pp. 28–30.

1899. HAY, W. P. Description of a New Species of Subterranean Isopod. *Proc. U. S. Nat. Mus.* Vol. xxi, pp. 871, 872.

SYNOPSIS OF THE ISOPODA (*continued*).

IV. ASELLOTA.

a. Eyes generally present. First pair of legs prehensile or subcheliform. Last three pairs of legs ambulatory, not natatory.

b. Three posterior segments of thorax not sharply marked off from the four anterior ones, and not smaller. Caudal segment large, shield-like. Eyes, when present, lateral or subdorsal, not placed on peduncle-like projections of the head. Superior antennæ issuing close together. Legs subequal in length.

c. Lateral parts of head scarcely expanded. Eyes, when present, small, lateral. Peduncle of inferior antennæ without small accessory appendage outside of third joint. Legs ambulatory, except first pair, which are distinctly subcheliform ; legs with dactylus generally uniunguiculate. First pair of pleopoda in female very small, not operculiform. Outer lamella of second pair very large and incrusted, so as to form, together with the corresponding lamellæ of the other side, a sort of operculum, covering the two succeeding pairs.

Family XV. Asellidæ

c'. Lateral parts of head lamellarly expanded. Eyes, when present, usually subdorsal. Peduncle of inferior antennæ generally with small accessory appendage outside of third joint. Legs ambulatory, except first pair, which are sometimes prehensile ; legs with dactylus generally bi- or tri-unguiculate. First pair of pleopoda in female transformed into a single, large operculum. Outer lamellæ of two succeeding pairs narrow and confluent with basal part . . . . Family XVI. Janiridæ

b'. Three posterior segments of thorax, as a rule, sharply marked off from four anterior ones, and much smaller. Caudal segment more or less vaulted above, subpyriform. Eyes, when present, placed on the tips of lateral peduncle-like projections of the head. Superior antennæ placed widely apart. First pair of legs much shorter than others. Succeeding pairs more or less rapidly increasing in length . . . . . . Family XVII. Munnidæ

a'. Eyes wanting. First pair of legs subprehensile. Last three pairs of legs natatory, with some joints flattened and ciliated. First pair of legs shorter than three following pairs. Second, third, and fourth pairs very elongate . . . . . . Family XVIII. Munnopsidæ

FAMILY XV. ASELLIDÆ (FRESH-WATER ISOPODA).

a. Mandibles without a palp. Last six pairs of legs with dactylus biunguiculate . . . . Mancasellus Harger

a'. Mandibles with a three-jointed palp. Last six pairs of legs uniunguiculate.

b. Eyes present. Body oblong, depressed. Head small, narrower and shorter than first thoracic segment. Caudal segment not longer than broad . . . . Asellus Geoffroy

b'. Eyes wanting. Body elongate, narrow. Head large, not narrower than first thoracic segment, and longer. Caudal segment much longer than broad . . . . Cæcidotea Packard

Genus Mancasellus Harger.

a. Lateral margins of head entire.

Mancasellus brachyurus Harger, Virginia

a′. Lateral margins of head not entire.

b. Lateral margins of the head with a deep cleft on either side.

Mancasellus macrourus Garman, Ky., Tenn.

b′. Lateral margins of the head with a large rounded sinus on each side in the middle.

c. External antennæ as long or longer than the body.

Mancasellus lineatus (Say), South Carolina

c′. External antennæ half as long as the body.

Mancasellus tenax Harger, Lake Superior

Genus Asellus Geoffroy.

a. Caudal stylets, or uropoda longer than terminal abdominal segment. Post-lateral margins of head without spines.

b. Caudal stylets broad and flattened. Propodus of first pair of legs much enlarged and subglobular, with a prominent acute tooth about, or a little above, the middle, and a lobe bearing one or two acute teeth near the base on its palmar margin.

Asellus communis Say, Conn., Penn., Ind., Ill., Mich., Miss.

b′. Caudal stylets extremely narrow and cylindrical. Propodus of first pair of legs narrow, elongate, without prominent acute teeth on its palmar margin.

Asellus attenuatus Richardson, Virginia

a′. Caudal stylets shorter than terminal abdominal segment. Post-lateral margins of head produced into prominent lobes bearing spines.

b. Post-lateral lobes bearing each several stout spines. Lateral margins of all the thoracic segments except the first with no emargination. Flagellum of first pair of antennæ consists of eleven to thirteen joints. Caudal stylets broad and flat, half as long as terminal abdominal segment . . . *Asellus brevicauda* Forbes, Illinois

b′. Post-lateral lobes bearing each a single spine. Lateral margins of all the thoracic segments except the first distinctly emarginate. Flagellum of first pair of antennæ consists of nine joints. Caudal stylets broad and flat, but narrower than in *A. brevicauda*, and three-fifths as long as terminal abdominal segment

Asellus intermedius Forbes, Illinois

Asellus tomalensis Harford, California

The description of this form is so meagre and insufficient that it is impossible to place it in the key with the other species of Asellus.

Genus Cæcidotea Packard.

a. Caudal stylets nearly half as long as body; basal joint or peduncle nearly twice as long as inner ramus; outer ramus from one-third to one-half as long as inner branch. First pair of antennæ short, reaching but little beyond the second joint of the second pair of antennæ.

Cæcidotea stygia Packard, Ind., Ill., Ky.

a′. Caudal stylets no longer than terminal abdominal segment; basal joint or peduncle shorter than inner ramus; outer ramus most as long as

inner branch. First pair of antennæ long, reaching to the end of the third joint of the second pair of antennæ, and being nearly twice as long as those of *C. stygia*.

Cæcidotea nickajackensis Packard, Tennessee

Family XVI. Janiridæ.

a. Eyes dorsal. Antennæ of the first pair well developed, with multi-articulate flagellum, or with flagellum rudimentary. Antennæ of the second pair long, with multi-articulate flagellum; peduncular joints not dilated. Mandibles with a three-jointed palp, and with cutting part separated from molar part by a deep incision.

b. Head without any true rostrum. First pair of antennæ extremely small, with flagellum rudimentary. Second pair of antennæ of moderate length, without any distinctly squamiform appendage. First pair of legs not prehensile. Uropoda extremely small, branches very short, nodiform . . . . Jæra Leach

b'. Head with prominent rostral projection, obtuse in front, or with a comparatively short rostral projection. First pair of antennæ well developed; flagellum multi-articulate. Second pair of antennæ very much elongated, with a well-marked, scale-like appendage outside of third joint. First pair of legs prehensile. Uropoda largely developed, with branches slightly unequal.

c. Head with lateral parts produced to very prominent acute lappets. Segments of thorax with lateral parts laciniate and produced. Caudal segment forming on each side, at the end, a triangular expansion . . . . Ianthe Bovallius

c'. Head with lateral parts not produced into lappets. Segments of thorax with lateral parts not produced, not laciniate. Caudal segment rounded, not expanded laterally . . Janira Leach

a'. Eyes lateral. Antennæ of the first pair small, with flagellum obsolete. Antennæ of the second pair short, with peduncular joints dilated, rudimentary flagellum composed of five articles, and equal in length to the width of the head. Mandibles with a three-jointed palp, and with cutting part composed of five teeth . . . Jæropsis Koehler

Genus Jæra Leach.

a. Anterior margin of the head broadly excavated on each side over the bases of the antennæ. Extremity of terminal segment notched for the insertion of the uropoda, the median point being almost imperceptible . . . . *Jæra marina* (Fabricius), *N*, surface

a'. Anterior margin of the head nearly straight. Extremity of terminal segment with a double excavation, the median point reaching the extremity of the sides . . . . *Jæra wakishiana* Spence-Bate, *A*

Genus Ianthe Bovallius.

a. Head with prominent rostrum.

b. Lateral margins of head produced into two angulations. Terminal segment of the body, with central posterior portion acute, triangular. Epimera evident . . *Ianthe triangulata* Richardson, *D*

b′. Lateral margins of the head produced in one anterior angulation. Terminal segment of the body, with central posterior portion nearly straight, rounded. Epimera not evident.

c. Rostrum as long as the head. Flagellum of first pair of antennæ 12-articulated, shorter than the breadth of the head. Flagellum of second pair of antennæ 50-articulated. First thoracic segment shorter than second. Second and third segments equal, and longest, much longer than seventh. Terminal segment smooth on dorsal side, without spine-like tubercle. Peduncles of uropoda longer than postero-lateral angulations of terminal segment. *Ianthe spinosa* (Harger), *N*, 80–100 fms.

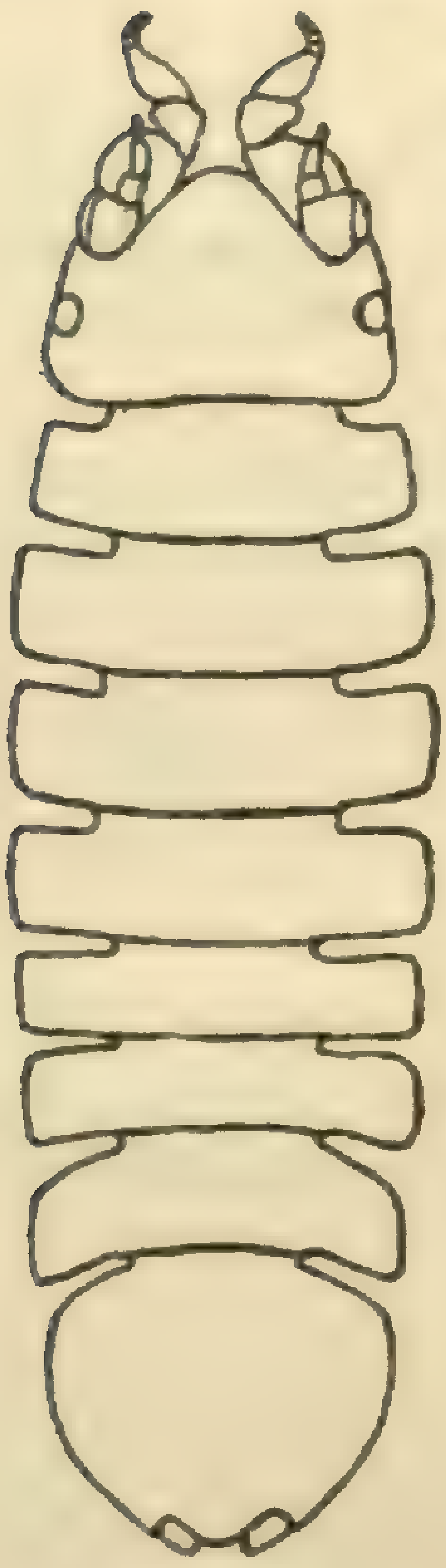


FIG. 12. — Jæropsis lobata.

FIG. 13. — Munna fabricii.

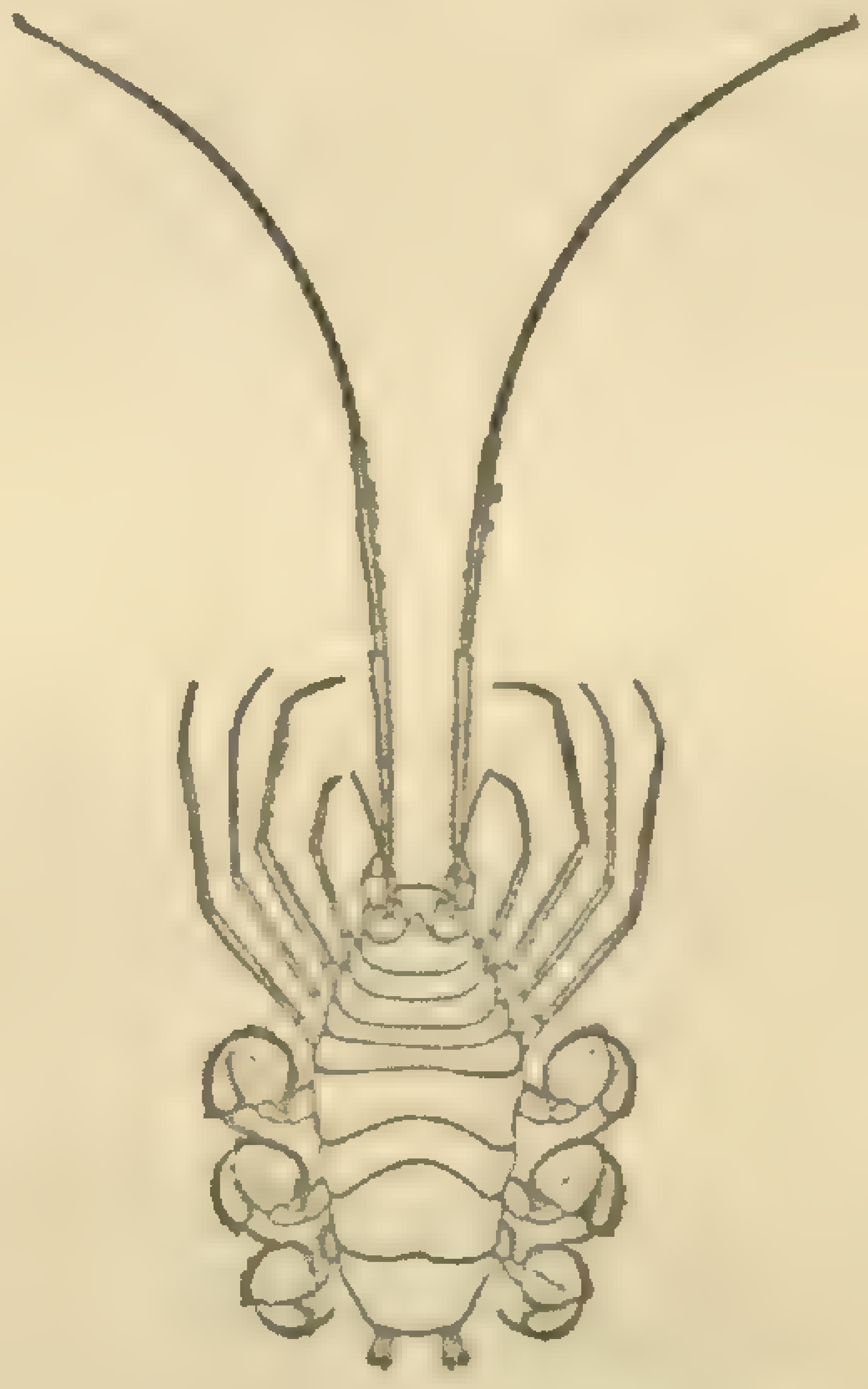


FIG. 14. — Eurycope cornuta.

c′. Rostrum much longer than head. Flagellum of first pair of antennæ 60–70-articulated, nearly as long as the breadth of the head. Flagellum of second pair of antennæ 280-articulated. First thoracic segment as long as second. Seventh segment longest. Terminal segment of body, with a single spine-like tubercle on its dorsal side. Peduncle of uropoda shorter than postero-lateral angulations of terminal segment of body . . . . *Ianthe speciosa* Bovallius, *N*

a′. Head without rostrum, in place of which is small median point. *Ianthe erostrata* Richardson, *A*

Genus Janira Leach.

a. Anterior margin of the head straight. *Janira maculosa* Leach, *N*, 100–116 fms.

a′. Anterior margin of the head not straight.

b. Front of head three-lobed, the center lobe subacute, rather longer than others, but not rostrate . . *Janira occidentalis* Walker, *P*

b'. Front of head produced in the middle in a short, sharp rostrum, and the antero-lateral angles of head also produced.

c. Antero-lateral angles of head sharp. Lateral margins of first four thoracic segments obtusely incised, each showing two broad angulations. Uropoda of female shorter than half the terminal segment; those of male as long as terminal segment of body . . . . *Janira tricornis* (Krøyer), *N*, 5–50 fms.

c'. Antero-lateral angles of the head shorter and less sharp. Margins of the first thoracic segment rounded, not emarginate. Uropoda alike in the two sexes, and as long as the terminal segment of the body.

Janira alta (Stimpson), *N*, 35–300 fms.

Genus Jæropsis Koehler . . . . . . *Jæropsis lobata* Richardson, *D*

Family XVII. Munnidæ.

Genus Munna Krøyer.

a. Caudal segment, with lateral edges evenly convex, and each armed with a single slender denticle ; apical lamellæ distinctly serrated. Eyes large. Superior antennæ, with flagellum composed of four joints, including very small apical joint. Flagellum of inferior antennæ longer than peduncle. Last pair of legs scarcely longer than body. Legs slender. Uropoda obliquely truncate at tip.

Munna fabricii Krøyer, *N*, 12–200 fms.

a'. Caudal segment, with lateral edges rather bulging in front, and each armed with four strong denticles; without any serrulated lamellæ. Eyes small. Superior antennæ, with flagellum composed of three articulations, including very small apical joint. Flagellum of inferior antennæ not attaining the length of the peduncle. Last pair of legs scarcely longer than anterior division of body. Legs shorter and stouter than usual. Uropoda produced at tip into several dentiform projections, one of which is hook-like.

Munna krøyeri Goodsir, *N*, 10–60 fms.

Family XVIII. Munnopsidæ.

a. Head of moderate size, deeply emarginate on each side for the insertion of the antennæ ; frontal part produced. First four thoracic segments transversely excavated dorsally. Superior antennæ, with flagellum multi-articulate. Natatory legs of the same structure, carpal joint foliaceous.

b. Body, with anterior division much broader than posterior ; three posterior segments densely crowded together. Caudal segment

oblong-oval. Mandibles without any molar expansion; cutting edge but slightly dentated. First two pairs of legs of same structure, though somewhat different in size; two succeeding pairs elongated. Dactylus wanting on natatory legs. Uropoda simple, biarticulate . . . . Munnopsis M. Sars

b'. Body, with anterior division less sharply marked off from posterior; three posterior segments very large and broad. Caudal segment semioval. Mandibles with molar expansion; cutting edge divided into strong teeth. First pair of legs shorter than three succeeding pairs, which are subequal in length, and very much elongated. Dactylus distinct on natatory legs. Uropoda biramous, branches single-jointed . . . . Eurycope G. O. Sars

a'. Head very large and broad, transversely truncated in front, lateral parts greatly expanded. First four thoracic segments slightly excavated transversely. Superior antennæ, with flagellum not much elongated. First two pairs of natatory legs of similar structure, carpal joint large and expanded, cordiform; last pair much narrower than two succeeding pairs, carpal joint but slightly expanded. Caudal segment triangular in form . . . . . . Ilyarachna G. O. Sars

Genus Munnopsis M. Sars . *Munnopsis typica* M. Sars, *N*, 20–122 fms.

Genus Eurycope G. O. Sars.

Eurycope cornuta G. O. Sars, *N*, 119–220 fms.

Genus Ilyarachna G. O. Sars.

Ilyarachna hirticeps G. O. Sars, *N*, 100–227 fms.

V. Oniscoidea (Terrestrial Isopoda).

a. Buccal mass not very prominent below. First maxillæ, with two plumose setæ on the inner plate. Mandibles with molar expansion obsolete, without any triturating surface, it being replaced by brush-like recurved setæ.

b. External antennæ generally long, close together, with antennal openings large. Body, as a rule, scarcely able to be contracted into a ball. Head less manifestly immersed in first thoracic segment. Lateral parts of the head separated by a vertical marginal and infra-marginal line. Clypeus arched. Legs generally long. Uropoda produced, reaching beyond the terminal segment of the abdomen and the preceding segment. Terminal segment narrower than preceding ones and conically produced at end.

Family XIX. Oniscidæ

b'. External antennæ generally short, with antennal openings small. Body able to be contracted into a ball. Head immersed in first thoracic segment. Lateral parts of the head undifferentiated. Clypeus perpendicular. Legs generally short. Uropoda short, flattened, not reaching beyond the terminal segment of the

abdomen or the preceding segment. Terminal segment short and broad . . . . Family XX. Armadillididæ

a'. Buccal mass prominent. First maxillæ with three plumose setæ on the inner plate. Mandibles with molar expansion large and broad, exhibiting a finely fluted triturating surface.

b. Head without any lateral lobes, frontal part rounded. Eyes well developed or wanting. Inner antennæ with last joint very small, and without distinctly developed sensory filaments. Posterior maxillæ with two thick hairy bristles. Maxillipeds with terminal part distinctly five-articulate, masticatory lobe truncate at tip, epignath short. External sexual appendages in male double. Inner branches of first pair of pleopoda of a similar structure in both sexes, that of second pair in male terminating in a long stylet. Both branches of uropoda styliform.

Family XXI. Ligiidæ

b'. Head with distinct, though not very large lateral lobes, front more or less produced. Eyes small or wanting. Inner antennæ with last joint well developed and tipped with a number of delicate sensory filaments. Posterior maxillæ without any bristles. Maxillipeds with terminal part generally imperfectly articulated, masticatory lobe terminating in a thin lash, epignath narrow, linguiform. Sexual appendage of male simple; inner branch of both first and second pairs of pleopoda transformed for copulative purposes. Uropoda with branches conically tapered.

Family XXII. Trichoniscidæ

Family XIX. Oniscidæ.

a. Flagellum of external antennæ biarticulate. External opercular ramus of the first, second, and rarely of the third, or all the pairs of abdominal appendages furnished with tracheæ.

b. Abdomen abruptly narrower than thorax. Epimera of all the abdominal segments small, subappressed.

Metoponorthus Budde-Lund

b'. Abdomen not abruptly narrower than thorax. Epimera of all the abdominal segments large, prominent, well developed.

c. Body very convex, capable of being rolled up into a perfect ball. Joints of the flagellum of the external antennæ subequal. Last abdominal segment reaching very little beyond the epimera of the preceding segment. External branches of the uropoda equal in both sexes. External opercular branch of all the abdominal appendages furnished with tracheæ.

Cylisticus Schnitzler

c'. Body more or less depressed, with lateral parts lamellarly expanded. Joints of the flagellum of the external antennæ with

the first joint generally longer than the second, often subequal, or even a little shorter. Last abdominal segment generally not reaching beyond the epimera of the preceding segment. External branches of the uropoda longer in the male than in the female. External opercular branch of the first and second pairs of abdominal appendages, and, in some of the species, of all the pairs, furnished with tracheæ . . . Porcellio Latreille

a'. Flagellum of external antennæ triarticulate. External opercular ramus of the abdominal appendages containing no special respiratory organ.

b. Front of head produced at the middle and at the sides in tubercles; lateral tubercles horn-like . . . . Alloniscus Dana

b'. Front and sides of head not produced in tubercles. With or without lateral lobes.

c. Abdomen abruptly narrower than the thorax. Epimera of thoracic segments small. Epimera of abdominal segments very small, but manifest. External branches of the uropoda styliform . . . . Philoscia Latreille

c'. Abdomen not abruptly narrower than thorax. Epimera of thoracic segments large. Epimera of abdominal segments large. External branches of the uropoda conical.

d. Surface of body granulated or tuberculate. Epimera of all the thoracic segments with the posterior angle acute. Basal article of the uropoda oblong, with the outer side obliquely carinated . . . . Oniscus Linnæus

d'. Surface of body setigerous, scarcely granulated. Epimera of the first three thoracic segments with the posterior angles roundly obtuse, of the fourth segment straight, and of the other segments acute. Basal article of the uropoda short and broad, with the outer side sulcate.

Lyprobius Budde-Lund

Genus Metoponorthus Budde-Lund.

a. Inner mala of the right mandible with four to five, of the left mandible with six pencils of hairs. Second and third joints of the peduncle of the second pair of antennæ furnished with a small apical tooth; first joint of flagellum much longer than second joint. No middle frontal lobe. Color brown, or reddish-brown.

Metoponorthus pruinosus Brandt, North America

a'. Inner mala of the right mandible with four, of left mandible with five pencils of hairs. Second and third joints of the peduncle of the second pair of antennæ without small apical tooth; first joint of flagellum shorter than second. Middle frontal lobe small, widely rounded. Color varying from gray to black, with three longitudinal lines of white spots . *Metoponorthus virgatus* Budde-Lund, Florida

Genus Cylisticus Schnitzler.

Cylisticus convexus De Geer, North America

Genus Porcellio Latreille.

a. Surface of body smooth.

b. Frontal median lobe of head rounded, a little produced. Articles of the flagellum of the external antennæ equal in length. Last segment of the abdomen with its extremity widely rounded.

Porcellio formosus Stuxberg, California

b'. Frontal median lobe of head more acute, minute. First article of the flagellum of external antennæ equal in length to the other, or a little longer. Last segment of the abdomen with its extremity acute . . . . . . *Porcellio lævis* Latreille, North America

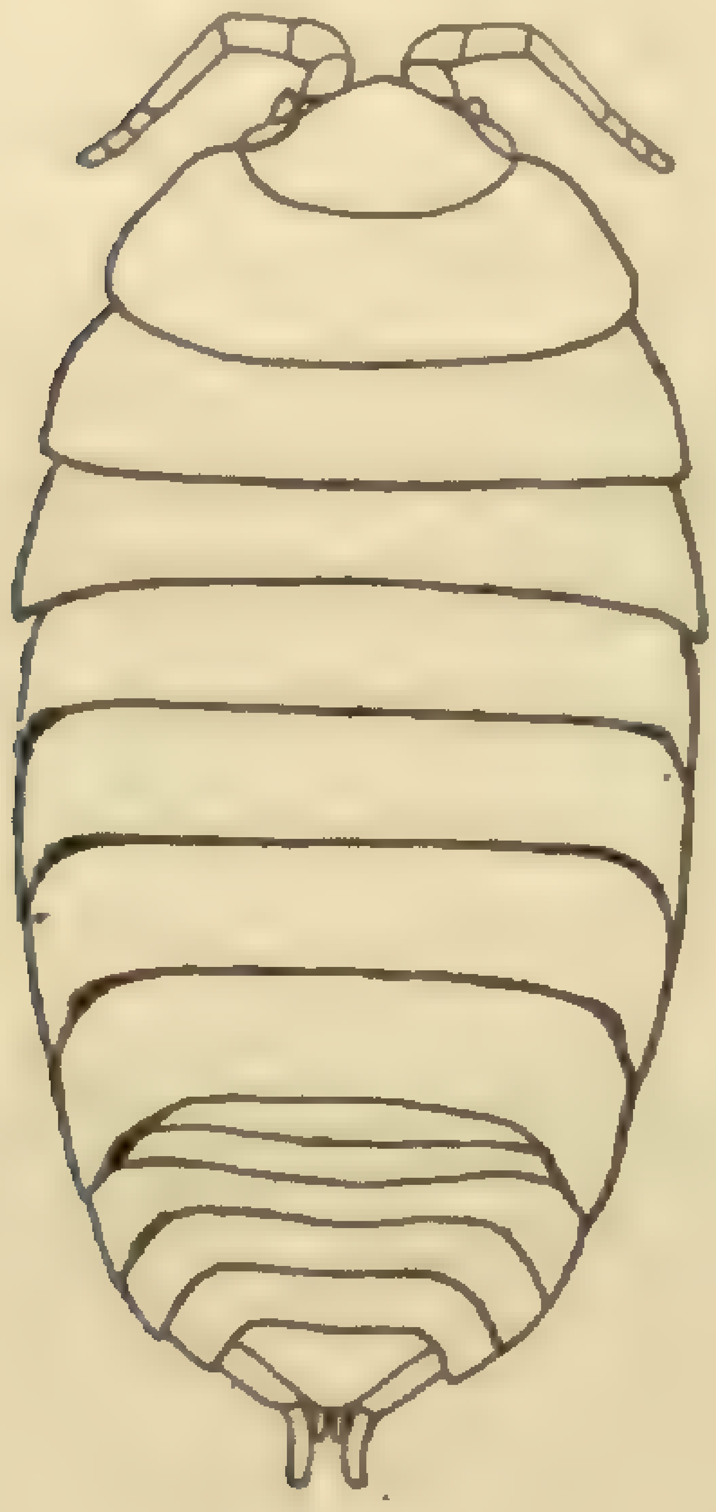


FIG. 15. — Alloniscus perconvexus.

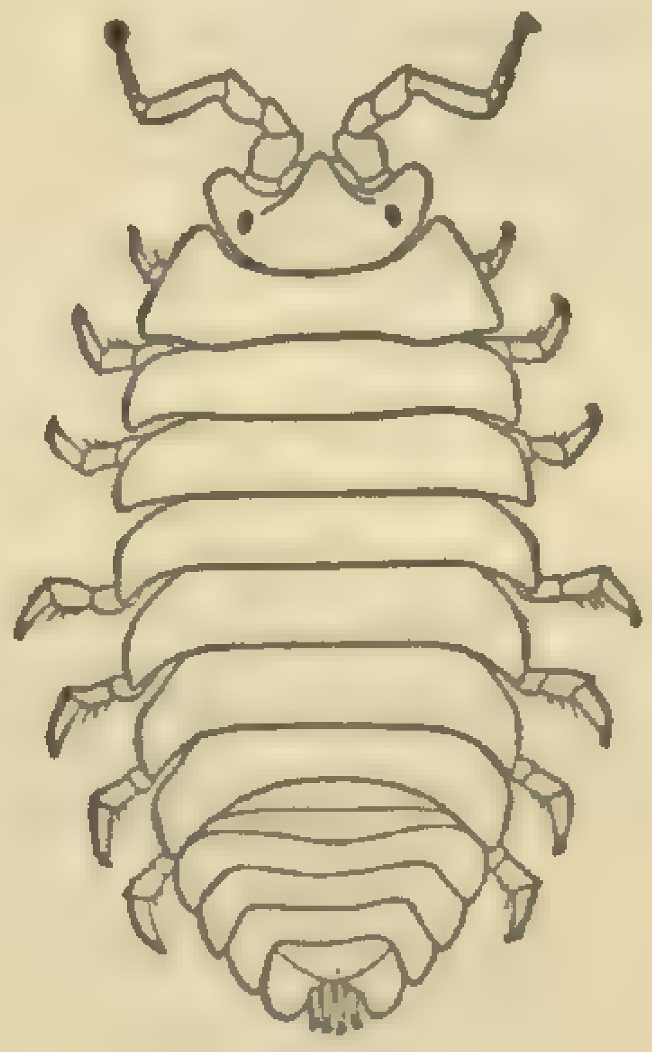


FIG. 16. — Actoniscus ellipticus.

a'. Surface of body roughly granulate or tuberculate.

b. Inner mala of the mandibles with four to five pencils of hairs. Body with spots.

c. Third joint of the peduncle of the second pair of antennæ furnished with a small apical tooth. Frontal lateral lobes of moderate size. Color varying from gray to black, with three longitudinal lines of white spots. Flagellum with joints subequal, or first shorter than second.

Porcellio rathkei Brandt, North America

c'. Second joint of the peduncle of the second pair of antennæ furnished with a large apical tooth. Frontal lateral lobes large. Color yellow; body spotted with black, spots arranged in longitudinal lines. Flagellum with first joint a little longer than second joint. *Porcellio spinicornis* Say, North America

b'. Inner mala of the right mandible with four to five pencils of hairs, of left mandible with seven to eight pencils. Body without spots. Frontal lateral lobes of head large, oblique.

Porcellio scaber Latreille, North America

Genus Alloniscus Dana.

a. Surface of body very densely granulated. Margins of epimera serrated.
Alloniscus mirabilis Stuxberg, California

a'. Surface of body punctate.

b. Lateral processes of head large, prominent.
Alloniscus cornutus Budde-Lund, California

b'. Lateral processes of the head small, scarcely prominent.
Alloniscus perconvexus Dana, Or., Cal.

Genus Philoscia Latreille.

a. Body smooth, without spines.

b. Body striped with two broad dorsal bands.
Philoscia vittata Say, North America

b'. Body not striped, but dotted with numerous spots.

c. Frontal marginal line straight. Color varying from black to brown, with white spots.
Philoscia nigricans Budde-Lund, Louisiana

c'. Frontal marginal line produced in the middle, a little arcuate. Color violet, with white spots.
Philoscia brevicornis Budde-Lund, Louisiana

a'. Body with numerous spines above . *Philoscia spinosa* Say, Georgia

Genus Oniscus Linnæus.

a. Caudal segment a little shorter than inner branch of the uropoda.
Oniscus asellus Linnæus, North America

a'. Caudal segment exactly equal to the inner branch of the uropoda.
Oniscus affinis Say, North America

Genus Lyprobius Budde-Lund.
Lyprobius pusillus Budde-Lund, California

Family XX. Armadillididæ.

a. Outer branch of the uropoda small or very small, smooth. Clypeus with the superior margin entire, lobated at the sides. First thoracic segment, often the second also, with the epimera posteriorly cleft, rarely entire. Exterior opercular branch of all the pleopoda furnished with tracheæ . . . . Cubaris Brandt

a'. Outer branch of the uropoda large, flattened, lamellar. Clypeus with the superior margin lightly sinuated, not lobated. Epimera of the first thoracic segments simple, entire. Exterior opercular branch of the first and second pairs of pleopoda furnished with tracheæ.
Armadillidium Brandt

Genus Cubaris Brandt . . *Cubaris californica* (Budde-Lund), California
Cubaris affinis (Dana), California
Cubaris pisum (Budde-Lund), Florida

Genus Armadillidium Brandt.
Armadillidium vulgare (Latreille). North America

FAMILY XXI. LIGIIDÆ.

a. Uropoda with branches equal in length, styliform, often filiform. Interior mala of the mandibles with numerous pencils of hairs. Last segment of body broad, with distinct epimeral plates. Maxillipeds with palp 4–5-jointed; epignath rounded . . . . Ligia Fabricius

a'. Uropoda with branches unequal in length.

b. Extremity of uropoda furnished with two long apical bristles. Interior mala of the right mandible with three pencils of hairs, of the left mandible with five pencils of hairs. Last segment of body small, and without any epimeral plates. Maxillipeds with a five-jointed palp; epignath narrow, linguiform. Ligidium Brandt

b'. Extremity of uropoda not furnished with two long apical bristles. Styloniscus Dana

Genus Ligia Fabricius.

a. External antennæ shorter than the body.

b. Uropoda about equal to half the length of the body. *Ligia occidentalis* Dana, *D*, Littoral

b'. Uropoda not equal to half the length of the body.

c. Uropoda equal to one-fifth the length of the body. *Ligia pallasii* Brandt, *AP*, Littoral

c'. Uropoda nearly equal to one-third the length of the body. *Ligia oceanica* (Linn.), *N*, Littoral

a'. External antennæ longer than body or equal to length of body. Uropoda about equal to two-thirds the length of body. *Ligia exotica* Roux, *D*, Littoral

Genus Ligidium Brandt.

a. Inner process of the basal article of the uropoda three times shorter than the external terminal branch; internal terminal branch reaching the apex of the external branch; the two terminal hairs equal in length to the external branch. *Ligidium hypnorum* (Cuvier), *P*, Littoral

a'. Inner process of the basal article of the uropoda four times shorter than the external terminal branch; internal terminal branch long, extending much beyond the apex of the external branch, being a sixth part longer; the two terminal hairs short, equal in length to half the external branch . . . . *Ligidium tenue* Budde-Lund, *A*, Littoral

Genus Styloniscus Dana . *Styloniscus gracilis* Dana, California, Littoral

Genus Euphiloscia Packard . . . *Euphiloscia elrodii* Packard, Indiana

This genus probably belongs here.

FAMILY XXII. TRICHONISCIDÆ.

a. Abdomen abruptly narrower than thorax. Head rounded in front, with distinct, though small lateral lobes. Terminal abdominal segment truncate at tip . . . . Trichoniscus Brandt

a′. Abdomen not abruptly narrower than thorax.

b. Head rounded in front, not lobated at the sides. Abdominal epimera but little developed . . . . Scyphacella Smith

b′. Head triangularly produced in front, with large lateral lobes. Abdominal epimera lamellarly expanded.

c. Body sculptured dorsally with more or less distinct longitudinal ribs. Terminal abdominal segment truncate at apex. Basal segment of the uropoda not simulating the epimera of the preceding segment . . . . . . Haplophthalmus Schöbl.

c′. Body not sculptured dorsally. Terminal abdominal segment rounded posteriorly. Basal segment of the uropoda simulating the epimera of the preceding segment . Actoniscus Harger

Genus Trichoniscus Brandt.

Trichoniscus pusillus Brandt, North America at Niagara

Genus Scyphacella Smith . . . *Scyphacella arenicola* Smith, *N*, Beach

Genus Haplophthalmus Schöbl.

Haplophthalmus puteus Hay, fresh water, Indiana

Genus Actoniscus Harger . . . *Actoniscus ellipticus* Harger, *N*, Beach

VI. Epicaridea.

a. Body of female distinctly segmented, more or less asymmetrical, twisted either to right or left. Maxillipeds lamellar, biarticulate, and more frequently exhibiting a small terminal joint. Legs seven pairs, sometimes obsolete on one side. Incubatory plates five pairs, more or less arching over the ventral surface of the thorax. Pleopoda forming simple or double lamellæ, all of the same structure, rarely obsolete. Male with all the segments of the thorax sharply defined. Last larval stage with the flagellum of the antennæ 4-articulate; legs of uniform structure; uropoda with inner branch shorter than outer. Parasitic on decapodous Crustacea.

Family XXIII. Bopyridæ

a′. Body of female perfectly symmetrical, the segmentation only visible, as a rule, in the middle of the dorsal face. Maxillipeds lamellar, without any terminal joint. Only five pairs of legs present. Incubatory plates comparatively small, sometimes greatly reduced in number, and scarcely at all partaking of the formation of the marsupium, which constitutes two separate cavities, bounded by the lateral walls of the body itself. Pleopoda generally rudimentary or wholly absent. Male with head and first segment of thorax coalesced. Last larval stage with the flagellum of the antennæ 5-articulate; legs of the first pair shorter and thicker than the others; uropoda with the branches subequal. Parasitic on Schizopoda.

Family XXIV. Dajidæ

FAMILY XXIII. BOPYRIDÆ.

a. Elongated appendages attached to the sides of the thorax in the female.
b. Branchiæ affixed to the sides of the abdomen in both sexes. Abdominal branchiæ in the male slender, cylindrical; in the female branching . . . . Ione Latreille
b'. Branchiæ affixed to the sides of the abdomen in the female. Abdominal branchiæ wanting in male; in female these appendages are simple sacs, not branching . . . . Argeia Dana
a'. Thorax in female without elongated appendages.
b. Body of female with one side greatly swollen and much longer than other. Segments of thorax only visible dorsally, coxal plates only present on shorter side. Abdomen consisting of five segments. Only first leg present on larger side, others wholly obliterated. Four pairs of pleopoda present. Male with abdominal segments fused . . . . Phryxus Rathke
b'. Body of female with neither side swollen. Thorax distinctly segmented. Abdomen consisting of six segments. All the legs present on both sides.
c. Pleopoda in female obsolete, replaced by fleshy ridges. Uropoda wanting . . . . Bopyroides Stimpson
c'. Pleopoda in female present. Uropoda distinct.
d. Legs of female with an adhesive process (exopod) attached to the coxal joint of the legs. This process is papillose in the first four pairs, rudimentary in the last three. Terminal joint of legs is inflated, without claw. Abdominal appendages elongated, coarsely pinnate.
Cepon Duvernoy
d'. Legs of female without exopod. Terminal joint of legs not inflated. Abdominal appendages not pinnate.
e. Pleopoda well developed, biramous.
Pseudione Kossmann
e'. Lateral margins of abdominal segments divided by marginal furrow into superior and inferior rami; inferior rami conical, papilliform; superior rami consisting of two equal elongated lamellæ.
Phyllodurus Stimpson

Genus Ione Latreille . . . . *Ione cornuta* Spence Bate, *A*

Genus Argeia Dana.

a. Head transverse. All the thoracic appendages present. All the abdominal appendages present . . . *Argeia pugettensis* Dana, *P*
a'. Head bilobate. Thoracic branchial appendages apparently absent in some of the anterior segments. Last three pairs of abdominal appendages wanting . . . . . . *Argeia depauperata* Stimpson, *P*

Genus Phryxus Rathke . . . . . *Phryxus abdominalis* (Krøyer), *N*

Genus Bopyroides Stimpson.

a. Margins of body, especially at the head, very acute and somewhat recurved. Lateral extremities of the abdominal segments sharply square-cut . . . . . *Bopyroides acutimarginata* Stimpson, *P*

a'. Margins of the body not acute . *Bopyroides hippolytes* (Krøyer), *N*

Genus Cepon Duvernoy . . . . *Cepon distortus* Leidy, *M*

Genus Pseudione Kossmann . . . . . *Pseudione giardi* Calman, *P*

Genus Phyllodurus Stimpson . . *Phyllodurus abdominalis* Stimpson, *P*

Family XXIV. Dajidæ.

Genus Dajus Krøyer . . . . *Dajus mysidis* Krøyer, *N*

REVIEWS OF RECENT LITERATURE.

ANTHROPOLOGY.

Annual Report of the Smithsonian Institution, 1897. — This volume contains a number of papers upon anthropological subjects, some of which have been reviewed in this journal.

"Mescal: a New Artificial Paradise" is described by Havelock Ellis from his own experience with the drug. Mescal — not to be confounded with the intoxicating drink distilled from the agave — is the blunt dried leaves of the cactus, called Anhalonium Lewinii. It is used by the Kiowa Indians and some other southwestern tribes. Though the use of mescal buttons is prohibited by the government, the practice of chewing them yet prevails among the Kiowas. "The rite usually takes place on Saturday night; the men then sit in a circle within the tent round a large camp fire, which is kept burning brightly all the time. After prayer the leader hands each man four buttons, which are slowly chewed and swallowed, and altogether about ten or twelve buttons are consumed by each man between sundown and daybreak. Throughout the night the men sit around the fire in a state of reverie, — amid continual singing and the beating of drums by attendants, — absorbed in the color visions and other manifestations of mescal intoxication, and about noon on the following day, when the effects have passed off, they get up and go about their business, without any depression or other unpleasant after effect." Mr. James Mooney called the attention of the Anthropological Society of Washington to this intoxicant in 1891. Dr. Weir Mitchell later published an account of the effects of the drug. Mr. Ellis describes the effects of mescal, especially the color visions, upon himself and also upon an artist friend.

Anthropological Notes. — Accompanying No. 4, Vol. X, of the *Bulletin of the Anthropological Society of Paris* is a list of the papers published by Dr. L. Manouvrier between 1880 and 1899. There are twenty-six titles classified as: "Scientific Philosophy"; "General Psychology"; "Reports"; "Sociology"; thirty-one as "Cerebral Anatomy and Physiology"; "Craniology"; "The Brain and

the Intelligence"; thirteen as "Evolution of the Human Species"; "Relations between the Function and the Organ"; twenty as "Ethnic Evolution"; "Ancient and Modern Races"; thirteen as "Abnormal Human Variations"; "Retrogression and Degeneration"; and twelve as "Anthropologic Technique."

In the *Bulletin de la Société d'Anthropologie de Paris*, Tome X, pp. 328–381, appears a valuable paper by M. G. M. Soularus, entitled "Recherches sur les dimensions des os et les proportions squelettiques de l'homme dans les different races." In his introduction M. Soularus reviews the history of the study of the long bones of the human skeleton from the time of White — whom he persistently calls "Witte" — to the recent investigations of Manouvrier, to whom he acknowledges his indebtedness for the idea of measuring the circumference of the bones and deriving an index by comparison with the length. One hundred and seventy-four skeletons were measured, of which thirty-four were of the white race, sixty-five of the black, thirty-two of the American, twenty-four of the yellow, and sixteen of the Malayo-Polynesian race.

The conclusions are that the femur is shortest among the Americans, and the largest among the Europeans. The average length of femur among the negroes is equal to that of the whites of North Africa. As to the yellow race, it occupies a median position between the whites and negroes. Though the femur of the Americans is the shortest, it is the largest in circumference. The European index and diameter is greater than the negro.

In the males the tibia is shortest among the yellow race and the Americans; negroes and Europeans are equal; the longest average occurs among the Polynesians. Here again the race with the shortest tibia has the bone of largest diameter.

The shortest humerus is found among the negroes, the longest among Europeans. The yellow race and the Americans have a humerus but little longer than that of the negroes. But the diameter, and hence the index, is always least in the negro group.

After comparing the individual bones of the two sexes the author arrives at the following general conclusions:

1. The average length of the bones, their circumference, and their index of section vary in each race and in each sex.

The relation of the circumference of a long bone with its length is also variable. In general, the shorter the bone the greater its relative circumference. Sexual differences are greatest in the yellow race and among Europeans, least among the Arabs and negroes.

2. The vertebral column varies equally in each race and in each sex, both in length and in diameter, as a whole and in segments. It is longest among people with short limbs, short among the negroes with long legs.

3. For each race and each sex the relation between the length of the femur plus the length of the tibia to the height of the body is determined. The importance of the index of cross-section is shown in this connection, for the stature is found to be less in the case of long bones with low indices and greater in the case of short ones with a high index than would usually be determined by the mathematical method.

"The Unity of the Human Species" is the title of a twenty-page article in which the Marquis de Nadiallac endeavors to establish the thesis that man belongs to a single species uniform in anatomical structure and in the manifestations of his intelligence. He says in conclusion: "By the side of the similarity of the anatomic structure of man in all times and of all races, I have sought to place the similarity of his genius, as proved by the identity of his conceptions. The ossuaries which contain the remains of his predecessors, the custom of coloring his bones red after they have been denuded of their flesh, the mysterious symbol to which we have given the name Swastika, and other conceptions, other almost universal creations, which it would be easy to add, all tend toward the confirmation of the knowledge given to us by the earliest arms, the first tools and implements of flint, and the most ancient pottery. We believe it impossible to misapprehend or mistake the proofs that flow from modern researches, all of which affirm with an irrefutable eloquence the unity of the human species."

"Recent Research in Egypt."—Dr. W. M. Flinders Petrie in a brief paper calls attention to the important discoveries made by archæologists in Egypt during the years 1895–97. During this short period the known history of the Nile Valley has been carried back a thousand years or more beyond what was previously regarded as the beginning of things. Now we look for the beginning many centuries before the pyramids, probably 5000 B.C., or even earlier.

Miss Fletcher's paper upon "The Import of the Totem," and that by Dr. Fewkes, entitled "A Preliminary Account of Archæological Field Work in Arizona in 1897," have been noticed in the *Naturalist* of January, 1898, and July, 1899.

"A New Group of Stone Implements from the Southern Shores of Lake Michigan" is the title of an attractively illustrated article by Dr. W. A. Phillips. Most of the implements are made from flakes; the trap cobblestones from which they were flaked do not readily lend themselves to the blocking out of blades from nuclei. F. R.

ZOÖLOGY.

Beasts.—The author of *Beasts*[1] belongs to that order of naturalists who, to the dread of housewives and maids and to the delight of all healthy boys, fill their pockets, cupboards, and rooms with reptiles and rodents of every description. From the pages of Mr. Kennedy's book we gather that a young crocodile occupied one shelf of his bookcase, a python another, and a pair of white rats a third. In one corner of the room stood the kennel of an armadillo; a vivarium abounding with salamanders, frogs, and tortoises stood by the window; and from somewhere emerged at night a potto, which became so hilarious that three several policemen roused the inmates of the house to warn them against burglars. The book is made up of short sketches of the interesting ways of all these creatures, and of many more, put together loosely, in a familiar style, the chief characteristics of which are sympathy for the whole range of the animal kingdom and a keen love of humor.

It is when animals refuse to behave after the rules laid down for them in the books that they have the greatest interest for Mr. Kennedy. When a toad, instead of rolling its cast skin into a ball and swallowing it with gusto, as it ought, takes it down "slowly and disgustfully"; when a tadpole "covers itself with ridicule" by trying to jump about before it has cast its long clumsy tail,—then it is that he thinks their actions worth chronicling. The curious awkwardness which some animals display in the capture of their food is the subject of some amusing pages. Worms, in particular, prove a severe test to the intelligence and patience of many of the reptiles. The "crass stupidity" of the lower reptiles prevents the author's interest in their habits from passing into affection. A white rat, however,

[1] Kennedy, Wardlaw. Beasts. Thumb-Nail Studies in Pets. London, The Macmillan Company, 1899. Illustrated with numerous drawings and photographs. 152 pp. Price $1.50.

and a mongoose evidently won a warm spot in his heart. The chapter on the mongoose, in particular, is a charming study of a fascinating subject. The almost human inquisitiveness of the creature, his fondness for toys and love of human fellowship, are lovingly dwelt on. Frequent reference to the need of care and thought for the wants of the creatures which are imprisoned as pets, is evidence of the author's sympathy for them and his acute observation of their habits. The final chapter of the book is on birds, which the author never deprives of their liberty; the chapter is a strong appeal against the terrible destruction of birds for millinery purposes.

A hearty, cheerful tone pervades the book, humorous turns of speech and thought abound, and if the style is now and then almost too colloquial, the fact is explained by the statement that the sketches were originally prepared for a school paper. Happy must be the boys under such a master; it would be hard for the dullest or the most thoughtless to come under his influence without acquiring a keener observation, a wider interest, and a more tender sympathy.

R. H.

Lake Urmi. — The natural history of Lake Urmi in northwestern Persia has been described by R. T. Günther.[1] The lake lies in the highlands that separate the river systems of the Atlantic, the Indian, and the Arctic Oceans and has no outlet. It has been described as "dead," but its waters, though containing about three-fifths as much saline matter as the Dead Sea, harbor a number of organisms. Masses of zoöglœa of micrococci invested by diatoms, and numbers of the brine shrimp, *Artemia urmiana*, find life possible in this water. It was estimated that about twelve hundred Artemias per cubic meter was a fair average for the whole lake. The fresh-water streams flowing into the lake contain fish which, when carried into the lake, are killed by its salinity. The conditions of the fish faunas of the several rivers indicate that the lake has for a long time been an efficient barrier to intercommunication. A description of the land fauna and flora surrounding the lake and a list of the local names of many animals are given. The paper also includes descriptions of the species of animals both recent and fossil collected by Günther, but worked up by other authorities.

P.

[1] Günther, R. T. Contributions to the Natural History of Lake Urmi, Northwestern Persia, and its Neighborhood. *Journ. Linnæan Soc. Zoöl.*, vol. xxvii, pp. 345-453, 1899.

Reissner's Fibre. — This fibre has been found by Sargent[1] to extend from the posterior end of the spinal cord anteriorly through the central canal and the ventricles of the brain to the anterior end of the optic lobes. The fibre was identified in representatives of all the chief groups and subgroups of the vertebrates, upwards of sixty different species having been examined. In no case where the material was perfectly preserved was the fibre absent. The uniformity of the fibre and the fact that it can be demonstrated by a great variety of methods lead the author to the conclusion that it is not an artifact, but a normal structure and probably nervous in character. The paper is accompanied by figures from photographs which demonstrate very conclusively the presence and position of the fibre. P.

Preliminary List of the Mammals of New York. — In 1842 Dr. J. E. DeKay published a work on the mammals of New York, giving descriptions of all the species then known to inhabit the state, with figures of most of them, this work forming Part I of the *Zoölogy of New York*, published under the authority of the state. Since that date no general survey of the mammal fauna of the state had been attempted till the appearance in 1899 of Mr. Gerrit S. Miller's "Preliminary List of the Mammals of New York."[2] As Mr. Miller says: "To write a preliminary paper on this subject fourteen years after the appearance of Dr. C. Hart Merriam's two volumes on the mammals of the Adirondack region, and fifty-six years after the publication of DeKay's elaborate work on the mammals of the state at large, may at first seem paradoxical"; but he gives good reasons for calling his list a preliminary one. He justly claims that "one of the most important results of the recent great increase in our knowledge of the mammalian fauna of New York is the realization that nothing more than preliminary work can be done now. The whole area of the state must receive a thorough biologic survey before final results can be expected." And what is true of New York, it may be added, is equally true of any other considerable area of North America, and probably of any other equal area of the world, so little is really known of mammalian life anywhere. Until within very recent years, the small mammals of no portion of this or any

[1] Sargent, P. E. Reissner's Fibre in the Canalis Centralis of Vertebrates. *Anat. Anz.*, Bd. xvii, pp. 33–44, Taf. I–III, 1900.

[2] Miller, Gerrit S., Jr. Preliminary List of New York Mammals. *Bulletin of the New York State Museum*, vol. vi, No. 29, October, 1899, pp. 271–390. Issued Nov. 18, 1899.

other country were more than superficially known, as witness the large number of new and previously unsuspected forms that have come to light through careful and systematic collecting in even the longest settled parts of the United States.

Not the least interesting part of Mr. Miller's paper is his historical summary of the work thus far accomplished in making known the mammalian life of New York State, in which he traces the gradual advance of our knowledge of the subject from 1842 to the present time. During the forty years immediately following the publication of DeKay's work only three species were added to the list of the state, while eighteen have been added during the last ten years. The total number of known New York mammals has been raised from fifty-six in 1842[1] to eighty-one in 1899, while doubtless others still remain to be added by further research. These additions are mentioned in chronological order, and also shown by a tabular arrangement. Thirty-one species have been described and named from New York specimens, of which twenty are now regarded as synonyms of previously described species. The type localities of all are given on account of their interest from the point of view of systematic zoölogy.

The eighty-one species and subspecies listed by Mr. Miller include eight cetaceans, two seals, and three introduced species of Old World rats and mice. Deducting these leaves sixty-eight species of strictly indigenous land mammals known as inhabitants of the state. In some six or seven instances increase in the total number of forms is due to the recognition of subspecies, two forms being recognized as occurring within the state instead of one, as in DeKay's time, as in the case of the red squirrel, chipmunk, flying squirrel, red-backed mouse, cotton-tail (three forms instead of one), mink, etc. Lumping these, as was formerly done, would reduce the number of New York mammals to about seventy-three as against the fifty-six known to DeKay.

In other words, the twenty-four additions to DeKay's list include sixteen species and eight subspecies, the latter being in most cases covered by DeKay's names.

The faunal areas, or "life zones" of the state, are considered at length, from the point of view of birds and plants as well as mammals. Following this is the list proper. Under each species are cited the authorities for the names adopted, and all the principal references to the species as New York animals. The text under each species is so arranged and subdivided as to give (1) the type

[1] DeKay gave sixty-five, but nine of these have proved invalid.

locality of the species; (2) its faunal position; (3) its habitat; (4) its distribution within the state; (5) its principal records for the state; and (6) remarks. The distribution of the various species within the state, and the citation of "principal records," are in general given with satisfactory detail. It hence seems strange that Dr. Holder's paper on the Atlantic right whale (*Balæna cisarctica*) should have been overlooked, especially since the paper (*Bulletin American Museum Natural History*, Vol. I, No. 4 (1883), pp. 99–138, Pls. X–XIII) was based primarily on a Long Island specimen, the skeleton of which has been on exhibition for twenty years in New York's greatest Museum of Natural History. A reference to Audubon and Bachman (*Quadrupeds of North America*, Vol. I, p. 148) on the former occurrence of the fox squirrel in New York would perhaps have been of interest.

We regret to see that Mr. Miller adopts Mr. Bangs's proposed change of name for the common deer, from the well-established and familiar Virginianus of Boddaert for Americanus of Erxleben. It would not be regrettable if Erxleben had really used the name in a nomenclatural sense for this deer, which he clearly did not do, or even intend to do. Erxleben says: "Differtne vere Americanus vti Pennanto videtur?" and then gives its differences from *Cervus dama*, and cites the authors who have written of it. As he wrote in Latin he naturally used the word "Americanus" in the sense of, Does the American deer truly differ? etc. The context shows that where he gave names to either species or varieties, they are given as marginal headings, as under, for example, *Cervus elaphus* (*Regni Animalis*, p. 301), where our elk or wapiti is named (p. 305) Canadensis = *Cervus elaphus γ Canadensis;* and so on throughout the "Systema Regni Animalis." The case of the common deer, as treated by Erxleben, is thus not at all parallel to that of the elk; in the latter case a name was formally given; in the former, only by a violent distortion of the author's evident meaning and intentions can a name be extracted from Erxleben for the Virginia deer.

Mr. Miller gives also a useful list of the fossil species thus far reported from the state, numbering five, as follows: peccary, horse, elephant, mastodon, and the big rodent Castoroides. A detailed bibliography of 103 titles concludes this interesting and important piece of work. We regret to see, however, that Mr. Miller was compelled to submit to a system of "editing rules in bibliography," so out of harmony with nearly all similar work in zoölogical bibliography, simply because they have been "adopted by the Regents of the University of the State of New York."

J. A. A.

The Trail of the Sandhill Stag. — We confess to a feeling of disappointment on laying down *The Trail of the Sandhill Stag*,[1] by Ernest Seton-Thompson. If it had been the first book by that author which had come to our notice, the feeling would probably have been one of interest and pleasure, but the standard set in *Wild Animals I Have Known* was so high that the present story, measured by it, fails to answer our expectations. For such of our readers as have not yet made the acquaintance of Mr. Seton-Thompson's style, the remedy against a similar disappointment is simple; let them begin with the story of the *Sandhill Stag* and then pass to the earlier and more fascinating work. In the story at present under consideration, as in his earlier stories, the author has attempted to tell the life story of a species by painting the portrait of an individual who possesses to an extraordinary degree the characteristics of his kind. In the present instance the subject is a black-tailed deer, a buck of marvellous size, crowned with an enormous pair of antlers. A boy, in whom the old barbarian instinct of the chase is overpowering, catches sight of the beautiful creature and pursues him on various occasions. Finally, after a long three days' chase over the snow, the stag, after seeing his mate murdered by one of the lad's more callous companions, is at last, and in spite of all stratagems, hunted to his lair, and comes face to face with his pursuer. The lad, however, is touched by the expression of nobility in the creature's gaze; his better nature asserts itself, and hunter and his intended victim part with an increase of mutual respect.

The moral of the story is obvious, perhaps too obvious. The service which the author's earlier work has performed in teaching love and sympathy for animals has undoubtedly been enormous, but it was done by revealing in an unusual degree the secrets of the creatures' lives. The reader shared their pleasures and anxieties, and unconsciously became their friend. In this later tale the boy's feelings rather than the stag's are portrayed.

If the story is a little less effective, the illustrations are as charming as ever, and the workmanship of the book itself reflects unusual credit on the designer and the publisher.

It is the hope of all who are watching Mr. Seton-Thompson's work that he may be able to reap, in the field which Mr. Hamilton Gibson tilled so faithfully, a splendid harvest. There is no more

[1] Seton-Thompson, Ernest. The Trail of the Sandhill Stag. With sixty drawings in black and white and a frontispiece in color. New York, Charles Scribner's Sons, 1899. 93 pp. Price $1.50.

effectual way to overcome the general indifference to the sufferings of our fellow-creatures than by spreading a knowledge of their tragic lives.

R. H.

Structure in the Mammalian Egg. — Professor Flemming[1] re-examines the ovarian eggs of the rabbit and finds that thin sections show a real reticulum of stained fibres. Previously, in the fresh eggs, he could not decide whether the fibres he saw branched and anastomosed or not. In the present preparations the yolk granules seem, when smallest, to be imbedded in the fibres, and the author thinks they arise there and only later get into the spaces of the network.

In the cavity of the Graafian follicle there is also a reticulum. This is regarded as the result of coagulation of the follicular liquid by the reagents used. It is not the same in normal as in abnormal follicles and is of a much finer mesh in small follicles. The network in the egg can be distinguished from that in the follicular liquid by its coarser, less regular spaces.

From the illustrations given, the reader might easily infer that the differences between the egg structure and the coagulum were merely of degree and not of kind, and see in them support for Alfred Fischer's contention that the so-called structure-reticulum is itself a coagulum. However, the author believes the egg reticulum to be the same as that seen in fresh material, and hence not the result of coagulation.

E. A. A.

Bob. — *Bob*[2] is a story that will appeal strongly to all lovers of animals. It will appeal also to lovers of literature. It is the story of a poet's mocking-bird told with a delicate humor, a keen and loving sympathy. To Lanier, as to many lovers of birds, there was something repugnant in the thought of caging a wild bird; Bob was, therefore, an unsought though welcome guest. The reader, however, lays down the little volume with the feeling that the bird's liberty could not have been sacrificed in a better cause. In this little volume, and in the sonnets which form the epilogue, Bob has certainly found a memorial such as falls to the lot of few.

The reader will naturally not look for a scientific study, a careful record of the number of feathers shed during the moult, or the

[1] *Festschrift Carl von Kupffers*, Jena, 1899.

[2] Lanier, Sidney. Bob. The Story of Our Mocking-Bird. New York, Charles Scribner's Sons, 1899. With sixteen illustrations in color. 64 pp. Price $1.50.

weight of food taken in a day; but he will find a charming study of the personality of the bird, and many graceful or playful reflections by the way.

The illustrations are from colored photographs, reproduced with an unusually pleasing effect. They represent various young mocking-birds in the attitudes described in the text.

R. H.

Our Native Birds. — This is a book[1] which should be within the reach of every school-teacher and of every person interested in preserving for future generations the wild life which forms so large a part of the attraction which nature exerts. The author begins with some of the statistics, which are now only too easy to obtain, of the steady decrease of song and game birds, and explains with unusual fairness the causes of this diminution. He gives full weight to a consideration very generally overlooked, namely, the destruction of shrubbery and the draining of wet places, incidental to the growth of towns and cities. Subsequent chapters are devoted to a description of the means by which we may prevent the destruction of birds and restock places from which they may have been driven. The better enforcement of the existing laws, or the enactment of new ones, particularly the introduction of gun license to reduce indiscriminate shooting, the spread of interest and knowledge through Audubon societies and the popular magazines and books, are urged with warmth, and at the same time with judgment. Interesting advice as to planting shrubs, vines, and trees, furnishing water for bathing and drinking, and allowing waste places to grow up with something that will furnish food and cover, is evidence of the practical character of the author's mind. The vexed question of the English sparrow's position is also treated with fairness, though many readers will take well-grounded exception to the method recommended for its destruction, *viz.*, the use of poison. The subject of hunting and of encouraging boys to hunt is hardly treated in a manner consistent with the tone of genuine sympathy for animals evident in the rest of the book. Throughout the book there are frequent references to authorities.

There is a marked absence of literary skill, both in the style and in the arrangement of the matter; it is not a book that one would read for amusement or for pleasure, but for those in search of help

[1] Lange, D. Our Native Birds. How to protect them and to attract them to our homes. With illustrations. New York, The Macmillan Company. 162 pp.

and advice in efforts to lessen the frightful destruction of wild life everywhere prevalent, the book will be an encouragement and an assistance.

R. H.

The Tree Frog. — A second interesting contribution to the natural history of European Amphibia by one who loves his subject is to be found in the *Quarterly of the Natural History Society of Zurich*, issued Feb. 15, 1899. H. Fischer-Sigwart, having previously described the life of *Rana fusca*,[1] now tells us of the habits of the tree frog, *Hyla arborea* L. The spawning, larval life, feeding, hibernation, etc., were studied both in the open and in his terrarium, where he kept many of these creatures (some for ten years), with greater satisfaction to himself than to his neighbors, who complained of the noise made by the ardent males. A tabulation of many observations upon the singing of these frogs and the state of the weather does not support the common belief in their powers as weather prophets, though showing that cold, stormy weather checks, as fine, warm weather increases, their musical efforts.

A long series of observations upon their color led to the result that they resembled the background in every case except one, slowly assuming various combinations of yellow, green, brown, gray, bronze, rust-red in harmony with the leaves, earth, cement, iron pipe, etc., they remained upon.

For details we must refer to the twenty-seven pages of the original.

E. A. A.

The Protoplasm of the Salmon Egg.[2] — Professor His has added another study to his previous noteworthy work upon the egg of the salmon. As before, he emphasizes the study of live material, while the interesting photographs that accompany his paper show, as far as photographs can, the appearance of preserved and sectioned material.

The protoplasm that collects in a heap (subsequently to divide into the cells of the blastoderm) acts, when removed from the egg, like a viscid liquid. It is made up of a clear "Hyaloplasma" and a turbid, granular "Morphoplasma." As development proceeds, these two parts undergo progressive changes in relative amount and arrangement. The changes in the distribution of these two parts

[1] See review in the *American Naturalist*, June, 1898.

[2] Protoplasmastudien am Salmodien Keim. *Abh. Königl. Sach. Gesell. Wiss.*, Bd. xxv, 1899.

of the protoplasm and the lack of any fixed permanent structure make one of the main theses of the author's work. His conception of the organization of protoplasm as derived from preserved material and from fresh material is that the Morphoplasm forms a framework enclosing Hyaloplasma in its meshes. In young cells the framework is uniform and fine meshed; later various modifications arise, so that the end result is very different in different cells and organisms. This morphoplasmic framework is continuous with the nucleus, and with the cell wall which is an actual membrane or modification of the framework and connected by radiating strands with the rest of the framework. The Hyaloplasma is a translucent, viscid liquid not visibly acted upon by reagents that act on proteid matter; it is thought to be inert, not living. Where large areas of clear Protoplasma, ectosarc, are seen to be contractile, it is really the Morphoplasma of the limiting membrane and of the few strands that pass through the liquid that is the real agent. When granules are seen moving through the Hyaloplasma they are supposed to be really in unseen strands of Morphoplasma.

The Morphoplasma is full of granules, microsomes, or plasmosomes. These may stand at irregular intervals, and hence there must be some substance to hold them together, *i.e.*, the strand is not merely a row of granules but consists of granules imbedded in a connecting substance supposed to be a viscid liquid not mixing with the Hyaloplasma. Though it is difficult to distinguish microsomes from yolk granules, secretions, etc., yet the author thinks there are real plasmosomes as essential elements of the strands of Morphoplasma. Though thus agreeing with Bütschli, that protoplasm has two non-miscible liquids as basis of its organization, the author does not accept the alveolar theory of structure as accounting for the morphoplasmic framework which is often seen as actual fibrils and not membranes.

As development proceeds, the undifferentiated protoplasm becomes differentiated, the meshes enlarge, the strands thicken and become fewer, and all the various specializations of cell division appear. Of the many interesting details of the latter phenomena here recorded, we will mention only the new interpretation of the well-known ring, or vesicle-like, appearances of the chromosomes as they are coming together in the formation of daughter-nuclei. The author thinks the Morphoplasma is prearranged in meshes of different size in different parts of the cell traversed by the chromosomes in moving from the equator of the spindle to the polar regions, and that when

they pass through the narrow meshed regions they assume a corresponding slender form, to expand later in the wider rings in the region of wider meshwork. The chromosomes are collections of chromatic granules which are arranged on the walls of the meshes, hence they outline a figure corresponding to the shape and size of the mesh. All this, the author concedes, would lend itself to the idea that we are dealing with an alveolar or vesicular structure.

The formation of new cell walls by the thickening and fusing of strands of the framework is apparently similar to the mode of making cell walls in the cleavage of echinoderm eggs as described by G. F. Andrews.[1] And the conception of chromatin granules moving along strands of protoplasm, as do granules in the pseudopodia of rhizopods, is also the same as the flowing or filose movements there described for the interalveolar plasma in various animal tissues and eggs. Considerable space is given to the description of remarkable amœboid movements performed by the cells of the blastoderm; they may send out very long finger-like pseudopodia which are at first chiefly clear Hyaloplasma but may become granular and be withdrawn. These activities, however, are not known in the normal state, but seem to be called forth by the stimuli that come to the blastoderm when removed to a compressorium for observation. Among other interesting observations we will mention only the occurrence of multiple asters in eggs that had not been fertilized, a phenomenon similar to that observed by T. H. Morgan[2] in echinoderm eggs. The unfertilized eggs of the salmon may be kept in running water for weeks without losing life. In the rainbow trout, also, unfertilized eggs were not dead at the end of several weeks.

Sections of such eggs kept seventeen days show numerous asters in which the radiating lines connect with a rather uniform mesh of the morphoplasm or else with the rays of other asters. At the center of each aster is a group of granules, representing the centrosome.

E. A. A.

Embryology of Invertebrates.[3] — The first part of the original German edition of Korschelt and Heider's Embryology of the Invertebrates appeared in 1890, and the last part in 1893. The translation

[1] The Living Substance. *Journ. of Morphol.*, Supplement 1897.

[2] The Action of Salt Solutions, etc. *Roux's Archiv*, Bd. viii, 1897.

[3] Korschelt, Dr E., and Heider, Dr. K. Text-book of the Embryology of Invertebrates. Vol. i translated by E. L. Mark and W. M. Woodworth; vols. ii and iii translated by M. Bernard and revised and edited by M. F. Woodward. The Macmillan Company.

of this monumental work was undertaken by Mark and Woodworth, and the first part of the English edition was published in 1895. Since then the translation has been continued by Matilda Bernard, under the editorship of Martin F. Woodward; and last year two additional parts were issued. The portion of the work thus far rendered into English represents about two-thirds of the German text, the chapters on the mollusks, tunicates, and amphioxus having not yet appeared in translation. From these facts it might be inferred that translation was a more time-consuming process than original composition, but the true explanation is doubtless found in the liberal opportunities given to German teachers for work of this kind as compared with that afforded to Englishmen and to Americans.

The body of the work is well translated, and although considerable freedom is sometimes taken in the adjustment of the substance of a paragraph to its new dress, we have found no place in which this change can be said to have seriously altered the sense. In comparing the several parts, we are inclined to believe that the first is more closely translated than the remaining two.

The arrangement of materials is a model of exactitude. The coarse print, fine print, and notes of the original are rendered as such, and the editor's additions are always clearly indicated by brackets. The more recent literature is usually given in an appendix.

The incorporation of new material was evidently one of the most difficult problems confronting the translators. This naturally has been greatly increased in the last two parts, for the assimilation of almost a decade of embryological work is no small task. As a rule, this has been met by the insertion of the more important new titles in the Literature Appendices, and occasionally by the addition of footnotes. Unsatisfactory as this method often is, it is difficult to see how it could have been improved upon except by a rewriting of the original text.

The way in which Anlage shall be rendered into English is a question that confronts every English translator of German embryological work, and, as the solutions of this question seem to be as numerous as those who attempt it, one is not surprised that the translators of the last two parts should substitute for the word "fundament," used in the first part, their own choice, "rudiment." This calls for some defense, which is given in the preface to the second part, where Darwin's unfortunate use of "rudimentary" for "vestigial" is pointed out as a root of much evil. While this whole matter is one rather of convenience than of importance to the zoölogist, its

influence on future lexicographers must be at least confusing, and should even a small proportion of the terms proposed be adopted, the uninitiated might be led to believe that with a command of Anlage and Zug almost any idea could be expressed in German.

In one respect the English edition is a noteworthy advance over the German original. The latter is paged continuously and is concluded with a subject and an author's index. The English parts have each their own paging, a table of contents, and double indices, thus rendering them much more readily usable as reference books. It is to be regretted that this general improvement has not extended to the presswork. Unfortunately in this respect the English edition is decidedly behind the German. In the first and second parts the illustrations, particularly, lack the clearness of the German cuts, and in the third the muddiness of the figures is often a really serious defect. Notwithstanding these shortcomings, the unabridged translation of such a masterly work is a boon to the English-reading zoölogical student, and one can do no less than wish that good fortune may aid in the completion of so worthy a task. P.

A Recent Book on Insects. — In *Our Insect Friends and Foes, How to Collect, Preserve, and Study Them* (G. P. Putnam's Sons, New York and London, 1899. xix, 377 pp., 225 illustrations), Miss Belle S. Cragin gives directions for collecting,, raising, and preserving insects, brief notes on their structure, habits, and habitats, with more detailed notices of some of the commoner forms of hexapods and shorter accounts of related arthropods.

Miss Cragin's book shows a purpose so sincere, and her project is so praiseworthy, that it is especially unfortunate not to be able to commend her effort. The directions for the collection and preservation of insects, though not better than others equally available, do not seriously offend by what they contain or omit. The more detailed accounts, however, show so slight a personal knowledge with the subject that very little can be said in favor of the book as a guide to instruct young students or to quicken their interest in the study of insects.

The essential characteristics for a book on insects, written for young people, are an attractive literary style, clear, concise, and accurate statements arranged in logical, scientific sequence. Judged from this standpoint, Miss Cragin's book cannot be regarded as even moderately successful. It would be hard to find a book dealing with insects in which the orders and families are arranged in so confusing and unscientific a manner. Misleading and inaccurate statements

are frequent. The Coleoptera are said to include over eleven thousand species; a statement that is true, but surely an unhappy way of recording that more than eleven thousand beetles are credited to America, north of Mexico; the larvæ of some snout beetles have jointed legs; the firefly, with luminous thoracic spots, is incorrectly placed in the Lampyridæ; the Hercules beetle is not the largest true insect; more than one Termite is found in North America, and the northern range of the species credited to that region is far beyond Massachusetts; all tropical Phasmidæ do not have wings that look like leaves.

The repetitious character of the text is especially tiresome, and the list of books for reference wholly inadequate.

Finally, the illustrations are very evenly bad; it would take much search to find a more atrocious series. Figs. 89 and 92 are transposed.

S. H.

Sheep Tick. — The gross anatomy and histology of the female genital tract of *Melophagus ovinus* are described in detail by Pratt (*Zeitschr. f. wiss. Zool.*, Vol. LXVI, pp. 16–42, Pls. II, III), completing and extending the work of Leuckart (1858). Each ovary consists of two ovarioles, possessing two follicles apiece, and both ovaries and ovarioles alternate in the production of the ova. From the germarium are produced follicular, nutritive, and egg cells; while the ovarioles are similar to those of Musca, and the peritoneal covering of the ovary is peculiar only in its thickness and extent. The fused proximal portions of the oviducts form a median vessel serving as a receptaculum seminis and lying in the virginal female in a plane perpendicular to that of the uterus, later at an acute angle to it. The ducts of the two pairs of milk glands, which provide nourishment for the larva during intrauterine development, open by a single opening into the uterus; the anterior of the two pairs is more or less rudimentary. The structure of the vagina is such as to permit of extreme distention at the time that the fully developed larva is extruded.

R. H. Wolcott.

Nauplius Stage of Penæus. — Although F. Müller announced as early as 1863 that Penæus emerged from the egg in its nauplius stage, this statement remained unconfirmed, notwithstanding the fact that Penæus has been studied by several investigators, till the past year when Kishinouye[1] rediscovered this stage in material collected on the Japanese coast.

[1] Kishinouye, K. On the Nauplius Stage of Penæus. *Zool. Anz.*, Bd. xxiii, pp. 73, 74, 3 Figs., 1900.

Sense Organs of Nereis. — F. E. Langdon[1] has described three kinds of sense organs in the skin of *Nereis virens* Sars. The diffuse sense organs consist of groups of bipolar nerve cells whose bodies form a part of the external epidermis, whose peripheral ends extend as sense bristles into the surrounding water, and whose central projections are in the form of nerve fibres terminating probably as pericellular nerve baskets around ganglion cells in the central nervous organs. The diffuse sense organs are most numerous in those parts of the body most exposed to contact, and represent organs for mechanical and possibly chemical stimulation. The prostomium possesses an anterior and a posterior pair of cephalic organs, each of which consists of a group of bipolar cells whose peripheral processes end in the epidermis, and whose central processes terminate in the brain. The anterior pair differ from the posterior in that their cell bodies lie between epidermis and brain instead of in the brain. The third class of organs consists of groups of spirally arranged cells, hence called spiral organs. The central processes from these organs take a direction appropriate for nerve fibres, but have not been traced into nervous organs. Their function as epidermal eyes is, therefore, hypothetical.

P.

Breeding Infusoria. — As bearing upon the problem of death it is interesting to note that the doctor's thesis of Dimitri Jonkowsky[2] records some partial repetition of Maupas's famous work upon Infusoria. Maupas found degeneration and death befell many Infusoria when they were bred for many generations without conjugating, but that the change in the nuclear machinery that takes place in conjugation would start another long series of generations. That degeneration is necessary without such renewal seems less probable from the experiment of the present author, though his evidence is not conclusive. In the case of *Pleurotricha lanceolata* (Ehbg.) 458 generations were reared in eight months and yet no degeneration was found, except in a few cases in the last generation. He suggests the rapidity with which the animals breed, which was greater in Maupas's experiments, may be a factor in the occurrence of degeneration. Bearing in mind the sensitiveness of many Infusoria to the chemical and physical nature of the liquid they are reared in, it seems not unlikely that degeneration may depend upon other

[1] Langdon, F. E. The Sense Organs of Nereis virens, Sars. *The Journ. of Comp. Neurology*, vol. x, No. 1, pp. 1–77, Pls. I–III, 1900.

[2] *Verh. des Naturhist. med. Verlins zu Heidelberg*, Bd. vi, 1898.

factors than the lack of conjugation, and that we do not yet know any limit to the length of life these creatures may have under proper conditions.

E. A. A.

Swiss Infusoria. — The school of Swiss zoölogists at Geneva, under the able leadership of Professor Yung, has in recent years shown great activity in the investigation of the local fauna. This work has been of high order and is abundantly illustrated with lithographed plates. That an interest in the Infusoria would still linger in the home of Claparède is indeed to be expected, though a list of new genera and species of Ciliata from the environs of Geneva comes as a surprise. Nevertheless Dr. J. Roux has discovered there a dozen new ciliates whose structure and relationships he discusses at length in a recent paper.[1] He also describes and fully figures a score of other forms concerning which his studies have added important information. Of prime interest is his *Monomastix ciliatus* — a new member of the Mastigotricha which combines characters of the Ciliata and Flagellata, having the cilia and nuclear conditions of the former and the flagellum of the latter. An amplified description is given of *Lionotus vesiculosus* Stokes, originally described as from this country. The discussion of *Loxodes rostrum* sheds light on a number of controverted points; the animal is flattened dorso-ventrally, not laterally, and the peristome is ventral, though placed to the left, being bordered by fine cilia and transverse striæ which have heretofore been interpreted as long cilia. The genus should be removed from the Trachelina to a new family, Loxodina. Various American species of this genus have been ill-founded, resting merely on inconstant variations in color, number of nuclei, and excretory vacuoles. On account of its superb illustrations and the critical character of the discussions, this paper is of especial value to all American workers in this much neglected group, and it is to be hoped that Dr. Roux will continue his studies.

C. A. K.

Growth in the Rhizopodan Shell, after its formation at the time of the division of the parent, as maintained by Rhumbler, is contested by Penard in a recent paper.[2] In observed cases in a

[1] Roux, J. Observations sur quelques ciliés des Environs de Genève, avec la description de nouvelles espéces. *Rev. Suisse de Zoöl.*, tome vi, pp. 557–636, Pls. XIII, XIV, 1899.

[2] Penard, E. Sur la croissance supposée de la coquille chez les Thécamœbiens. *Arch. Sci. Phys. et Nat.*, IV Pér., tome vii, 23 pp., 1899.

number of species the new shell is usually as large as the older one, and when differences do occur, they are but slight and as often present larger shells as they do smaller ones. The differences in size among the individuals of a given species in one locality are usually small, the greatest number presenting the medium dimensions, while dwarfs and giants are equally rare. These extremes are examples of variation within the species and cannot represent the young and the old — the extremes of a growth series. The instances cited by Rhumbler of great differences in size are explained by the supposition that more than one species has been included in the series, the author contending here, as elsewhere, for the recognition of a greater number of species in this group. The process of repair, local growth about the mouth, resolution of the shell, and exuviation are none of them regarded as proofs of the growth of the shell as a whole. The author's extended observations on the Rhizopoda thus lead him to confirm the views of Verworn.

C. A. K.

Abyssal Rhizopoda. — Dr. E. Penard has recently published[1] an account of his interesting studies upon the Rhizopoda from the bottom of Swiss lakes. His attention was given to collections of the bottom ooze, from which he describes a characteristic fauna of peculiar species. Many of these are new, differing from the littoral species to such an extent as to necessitate, in the author's estimation, varietal or specific distinction. In numbers they exceed the stragglers from the shore fauna which occasionally invade the depths. The author does not favor the view that the Rhizopoda are sometimes pelagic in habit, and suggests that their floating is due to the gases of putrefaction. This is certainly not the case in some American waters where their numbers and activity entitle them to rank as planktonts. The abyssal Rhizopoda are most abundant at depths of 25–50 meters, being modified by shore contamination above that limit, and decreasing in numbers below it. Their distribution is widespread, though irregular as to species. During the winter season they decline in numbers as their food, the diatoms, is at a minimum at that time. In addition to the Léman, eight other Swiss lakes were explored, and the same types of abyssal Rhizopoda were found in all of them. This fauna, living under almost unchanging conditions of great pressure, low temperature (about 4° C.), little or no light, no currents, and little food but diatoms, exhibits certain

[1] Penard, E. Les rhizopodes du Lac Léman. *Rev. Suisse de Zoöl.*, tome vii, pp. 1–142, Pls. I–IX, 1899.

peculiarities. As compared with littoral species, those of deep water are more variable, being often irregular in shape or ornamentation, Quadrula, for example, lacking the regular arrangement of the plates of the shell. They are also of larger size, and are more transparent, being less heavily charged with salts of iron and manganese, which cause the brownish and purplish tints of the shell. The contractile vacuoles are less active, as they are in those species also which inhabit sea-water, and the capacity of encystment seems in large measure to have been lost. Starch grains are frequently found in the protoplasm, though no Zoöchlorellæ were detected. The author suggests that diatoms may be retained within the protoplasm for a considerable length of time undigested in a temporary symbiotic relationship. On account of the great similarity of the abyssal Rhizopoda of the different lakes not at present connected, the separate origin of these faunas from the common littoral group is not accepted, and the idea is advanced that they represent a relict fauna of the preglacial or glacial period.

C. A. K.

A New Colonial Flagellate. — The Illinois State Laboratory of Natural History has recently issued a bulletin[1] on *Platydorina caudata*, an interesting new genus of the family Volvocidæ, described by C. A. Kofoid. This is a colonial form of sixteen or thirty-two biflagellate cells arranged in a horseshoe-shaped cœnobium which bears three or five tails, formed by the envelope at the posterior end. The cœnobium is flattened, and is slightly twisted in a left spiral. The cells appear to be arranged in one layer, and the two faces of the plate are exactly alike, as alternate cells upon either face bear flagella. In development the young colonies pass through a Gonium and a Eudorina stage and subsequently flatten, so that the cells of the two faces are regularly intercalated. This genus presents the most pronounced type of functional and structural polarity, and exhibits a greater degree of axial differentiation than any other genus of the family. The organism has been found in late summer and fall months for four years past, and has occurred in the waters of the Upper Mississippi, Illinois, and Wabash basins. The paper contains a key to colonial Volvocidæ.

[1] Kofoid, C. A. Plankton Studies. III. On Platydorina caudata, a new Genus of the Family Volvocidæ, from the Plankton of the Illinois River. *Bull. Ill. State Lab. Nat. Hist.*, vol. v, pp. 419–440, Pl. XXXVIII, 1899.

Sporulation in Amœba. — C. Scheel[1] describes and figures a most interesting method of reproduction in *Amœba proteus* observed in the winter of 1897–98. The conditions leading to this hitherto unknown method of rapid increase in this fresh-water Amœba could not be determined, nor could various experiments bring about the same results in material from the same locality, examined in 1898–99.

The Amœba was studied both alive and in prepared sections and a pretty complete series of stages obtained.

The creature draws in its pseudopodia, takes on a spheroidal form, and then secretes a cyst or case that ultimately shows three successive layers. Within this the Amœba rotates rapidly, once a second, in all directions with frequent change; it looks as if ciliated, but no evidence of cilia was found, and its motions may be due to pseudopodia. After several days this rotation ceases.

In one case a contracting vacuole was seen discharging rhythmically to the exterior, when the cyst was partly formed.

The nucleus divides into pieces, and when there are about 20–30 they become arranged near the surface. These in turn continue to divide until 500–600 small nuclei are formed in the outer part of the Amœba, while the central part has none. Cell walls appear about the nuclei, first about the outermost ones, and gradually the pieces of protoplasm so circumscribed separate as small Amœbas. These break out through the cyst, which has in the mean time become softened and broken up.

The whole process lasts from two and a half to three months.

In this way hundreds of small Amœbas, 10–14 μ in diameter, are set free at one time.

The author was able to isolate the young and rear them to recognizable *Amœba proteus* in two and a half to three weeks. E. A. A.

Notes. — The second number of Vol. I of the *Biological Bulletin* contains the following articles: "The Early Stages in the Development of the Hypophysis of *Amia calva*," by J. M. Prather; "An Extraordinary New Maritime Fly," by V. L. Kellogg; "On the Variation in the Position of the Stolon in Autolytus," by P. C. Mensch; "Gordiaceæ from the Cope Collection," by T. H. Montgomery, Jr.; and "A Preliminary Account of the Spermatogenesis of *Batrachoseps attenuatus*, Polymorphous Spermatogonia, Auxocytes, and Spermatocytes," by G. Eisen.

[1] Beiträge zur Fortpflanzung der Amoeben. *Festschrift Carl von Kupffers*, Jena, 1899.

The first number of Vol. X of the *Journal of Comparative Neurology* contains "The Sense Organs of Nereis virens, Sars," by F. E. Langdon; "The Roof and Lateral Recesses of the Fourth Ventricle, Considered Morphologically and Embryologically," by J. A. Blake; "Observations on the Weight and Length of the Central Nervous Organs and of the Legs in Frogs of Different Sizes," by H. H. Donaldson and D. M. Schoemaker; and "A Report of the Neurological Seminar of the Marine Biological Laboratory, Woods Holl, Mass., for the Season of 1899," by A. D. Morrill. The number also contains an obituary notice of Fanny E. Langdon, by Professor Reighard, and the usual literary notices.

Miss K. J. Bush has published in the *Proceedings of the Academy of Natural Sciences* of Philadelphia a description of a number of new species of gastropods belonging to the genus Turbonilla from the western Atlantic fauna. The paper includes a synoptic list of species and a thorough revision of the synonymy, based upon examination of a number of museum collections.

Dr. S. Prowazek has published in Vol. XI of the Vienna *Arbeiten* a very exhaustive and fully illustrated account of the conjugation of *Bursaria truncatella.* He also contributes many interesting observations on the structure, nutrition, excretion, encystment, conjugation, division, and parasites of *Stylonychia pustulata.*

The Echinorhynchi parasitic in Cetacea have been brought together in a critical discussion by Shipley (*Arch. Paras.*, Vol. II, pp. 262–269).

In a paper on the Porocephali of the dog and some other mammals, Neumann[1] shows that, contrary to the generally accepted belief, the larval forms of these parasites are not accustomed to abandon their cysts, but probably perish in them, and that, except in rare cases, they are harmless to their hosts. The larval form of *P. constrictus*, which is recorded as a dangerous parasite of man in Africa, is probably as innocuous as other species, and certainly was not the cause of death in the cases reported.

A revision of the Echiurida and a discussion of their geographical range are appended by Shipley[2] to his account of the forms collected

[1] Neumann, G. Sur les Porocephales du chien et de quelques mammiferes. *Arch. Paras.*, tome ii, No. 3, pp. 356–361, 1899.

[2] Shipley, A. E. On a Collection of Echiurids, etc. A. Willey's *Zoöl. Results*, pt. iii, pp. 335–356, 1 plate, May, 1899.

by Dr. Willey. He lists a total of thirty-one good species, belonging four to Bonellia, four to Echiurus, one each to Hamingia and Saccosoma, and twenty-one to Thalassema, for which genus a good analytical key is given. From the geographical distribution some interesting points are excerpted. Bonellia favors warmer or temperate waters; Echiurus, colder regions in both hemispheres, without known species in connecting regions; Hamingia and Saccosoma are both northern forms. Of Thalassema the only species found outside of tropical and subtropical seas occur at points under the direct influence of the Gulf Stream.

A gape worm, Syngamus, has been reported by Railliet (*Compt. Rend. Soc. Biol.*, March 4, 1899), which, like that recorded by von Linstow (*Amer. Nat.*, Vol. XXXIII, p. 903), infests herbivorous mammals; it appears to be common in Annam cattle, but, unlike its avian congeners, harmless.

The rhynchodæal glands of Tetrarhynchus have been subjected to a careful study by Pintner.[1] These glands, which correspond to the greater part of the structures interpreted by Lang as rudimentary salivary glands, stand in close relation to the probosces, that is, to organs which are peculiar to a well-circumscribed group of animals aberrant in character. Their distribution, form, and chemical reaction show them to be most closely related to the cephalic glands of nemertines. They are neither cystogenic, nor mucous glands, and no evidence was found as to their real function.

Simondsia paradoxa, the extraordinary nematode described by Cobbold, has been found again by von Rátz (*Zeitschr. f. Thiermed.*, Bd. III, pp. 322–329), whose brief report covers chiefly pathological data.

A monograph on the Strongylidæ adds another to the valuable series of taxonomic summaries on groups of parasites, published by Stossich.[2] An analytical key to the subfamilies and genera is followed by descriptions of the species. The references to the literature on each species are particularly full, but the nomenclature is open to some criticism. A comprehensive list of hosts and a good index, including synonyms, add much to the usefulness of the paper.

[1] Pintner, Th. Die Rhynchodäaldrüsen der Tetrarhynchen. *Arb. Zool. Inst. Wien*, Bd. xii, pp. 1–24, 3 plates, 1899.

[2] Stossich, M. Strongylidæ. Lavoro monografico. *Bull. Soc. Adriat. Sci. Nat. Trieste*, vol. xix, pp. 55–152, 1899.

BOTANY.

The Cyclopedia of American Horticulture.[1] — It has been the dream of years with Professor Bailey of Cornell to close the nineteenth century with a comprehensive index to American horticulture, viewing plants from the garden rather than the herbarium, and considering them as living, growing, varying things rather than bibliographical formulæ. To this end he spent a year in indexing all of the prominent American plant and seed catalogues, as a preliminary step, and then enlisted the interest and services of a large number of artists, expert gardeners and botanists, with whose coöperation he now has the work so well in hand that the first of the four volumes of which it is to consist is given to the public with the promise that the others shall be issued before the end of the year.

The volume already published, covering the initials *A* to *D*, is a quarto of over 500 pages, illustrated by a number of full-page plates, and nearly 800 cuts in the text; and, as is the plan of the entire work, is made first hand, from original sources of information, the botanical matter nearly all newly elaborated from the living plants, and the cultural directions often repeated by several growers experienced in methods adapted to American conditions. The editor very modestly says that he considers his book only a beginning, bringing together scattered data as a foundation for other studies. It is sufficient to say that it is well written, well printed, and, though unequally so, well illustrated.

The botanical treatment of so large and shifting a subject as the plants cultivated in a given country is a matter of some interest. Florists' and gardeners' varieties, because of their very transient nature and great number, are not characterized nor even enumerated, though the types under which they may be grouped are considered in the more popular genera of the moment. But the species and more permanent varieties are systematically handled, and the very real objection, that the systematic treatment of the plants grown in a single country deals with too shifting a quantity to have value of any permanence, is to a certain extent met by the introduction under the more important genera of supplementary lists of species which should be, or are likely to be, elements of our trade.

Nomenclature in botany is sufficiently difficult and complex to

[1] Bailey, L. H., and Miller, Wilhelm. Cyclopedia of American Horticulture. New York, The Macmillan Company, 1900.

furnish occupation for a large number of thinkers and writers, and when the transient forms evolved under the hand of man and advertised and marketed in accordance with prevalent business methods have to be taken cognizance of, it becomes almost a pigs-in-clover proposition. For some years past the leaders in horticultural thought have been agreed on the adoption of simple and short vernacular names for such forms, and official action tending to secure a consistent application of principles of good taste, good sense, and business wisdom has been taken at various times by the American Pomological Society, the representatives of the principal experiment stations, and the Society of American Florists, while in 1893 a botanical congress at Madison, on the report of a committee of international membership, endorsed the actions of these bodies with the recommendation that, for practical reasons, the great Index Kewensis be taken as the basis of nomenclature for the more permanent forms bearing Latinized names. These various conclusions have been made the working basis of the *Cyclopedia*, and although the partitioning of the work among many persons has made the results attained less uniform than would have been the case if one person had done it all, the book is going to place in the reach of makers of American trade catalogues a model which they can follow, and which it will be to their ultimate business interest to follow; while such action on their part will do very much to raise the semi-science of the botany of cultivated plants to a position where the general monographers of plants can take cognizance of and utilize its great array of facts — a result which in one way or another the first half of the twentieth century must see achieved.

T.

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A MONTHLY JOURNAL
DEVOTED TO THE NATURAL SCIENCES
IN THEIR WIDEST SENSE

CONTENTS

		PAGE
I.	**Marine Biology at Beaufort** . . . . Professor H. V. WILSON	339
II.	**The Fruiting of the Blue Flag (Iris versicolor L.)** Professor J. G. NEEDHAM	361
III.	**A Contribution to the Natural History and Development of Pennaria tiarella McCr.** . . . Professor CHAS. W. HARGITT	387
IV.	**The Ornithological Results of the Polar Expedition under Dr. Nansen** . . . . R. W. SHUFELDT	417
V.	**Synopses of North-American Invertebrates. IX. The Scorpions, Solpugids, and Pedipalpi** . . . . . . NATHAN BANKS	421
VI.	**Reviews of Recent Literature:** *Anthropology,* The Natural History of the Musical Bow, Report of the U. S. National Museum, 1897, Report of the Commissioner of Education for 1897–98, Notes	429
	— *General Biology,* Protoplasmic Streamings	434
	— *Zoology,* A New Practical Zoology, Gogorza's List of the Vertebrate Animals of the Philippines, Lungless Salamanders, The Egg of the Hagfish, Waite's Fishes of the Thetis Expedition, Smitt on Lycodes, Abbott on Chilean Fishes, Moreno on the Olfactory Nerves of Fishes, California Water Birds, Ovogenesis in Tunicates, Reproduction of Amœba, Arctic Deep-Sea Fauna, Arctic Marine Animals, Notes	436
	— *Botany,* Phenological Observations in Canada, King's Irrigation and Drainage, Trimen's Flora of Ceylon, Nuclear Phenomena in Ustilagineæ, Cell Division in Sporangia and Asci, Notes	445
	— *Petrography,* The Petrographical Province of Essex County, Mass., Nepheline-Syenites, Notes	453
VII.	**Publications Received**	456

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THE

AMERICAN NATURALIST

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MARINE BIOLOGY AT BEAUFORT.

H. V. WILSON.

THE sandy strip of land which extends along the North Carolina coast, separating the ocean on one side from the system of sounds on the other, is interrupted at intervals. The breaks or inlets thus convert the strip into a series of long, narrow islands, known as banks. On the mainland, opposite the inlet between Shackelford and Bogue banks, is the town of Beaufort, some 350 miles south of Baltimore and 250 northeast of Charleston. The coast line here runs nearly east and west, and Beaufort is at the end of a little peninsula which juts out from the mainland toward the south, and is nearly surrounded by water. Beaufort inlet is a mile and a half in width, and it is about the same distance, in a straight line across the harbor, from the town to Fort Macon, at the extreme end of Bogue bank. The harbor occupies an area some four or five miles wide, passing to the east and west into the shallower waters of Back (opening into Core, thence into Pamlico) and Bogue sounds, respectively.

The harbor is diversified with numerous sand shoals, mud flats, salt marshes, all more or less submerged at high water;

at which time, with the centerboard up, a "sharpy" (the favorite form of sailboat, imported here from Connecticut) may be sailed in a straight line from the inlet to the town. Behind the protecting shoals the water is always quiet, so that one may go collecting in this part of the harbor in a skiff at times when the breakers are high in the inlet and running freely along the seaward edge of the shoals. The wealth of life buried in the sand shoals and mud flats is remarkable — every spadeful

FIG. 1. — BEAUFORT HARBOR. After U. S. C. and G. S. Chart 420.

brings up something. Worms are of course best represented, although sea anemones, holothurians, spatangoid urchins, burrowing Crustacea, and mollusks abound. The natural absence of rocks over the bottom forces the sessile forms to make use of whatever will afford a foothold. Diopatra tubes become covered with ascidians, these with algæ, hydroids, polyzoa, and small tubicolous annelids. Algæ and sponges fasten on partially submerged shells. The oyster beds ("oyster rocks" in the local vernacular) distributed round the margin of the flats afford a home for many other attached mollusks, and for anemones and sponges, while crabs, gasteropods, nudibranchs, ophi-

urans crawl about over the shells, and burrowing shrimps bury themselves in the mud beneath and between them.

Passing from the shoals into the deeper water of the harbor channels, the bottom is found in places to be sandy, elsewhere muddy or covered with a shelly detritus. In many places one may collect with a long-handled scraping net, working from a skiff or sailboat. But for any extensive bottom collecting the dredge and trawl, with a steam launch, are necessary. Sponges, sea feathers and fans, the beautiful Renilla, Astrangia and rarely other corals, starfish, sea urchins, sand dollars, bottom-loving shrimps, crabs, mollusks are thus taken.

The sea bottom outside the inlet, within five or six miles off the coast, has been pretty well explored with dredge and trawl. Near shore, in many places, the bottom is a sticky mud, covered with sand dollars and with abundant medusæ (Chiropsalmus). A sandy bottom is more common. The slope is gradual, the depth at five miles from the beach line being, in general, eight to nine fathoms. Many forms which are commonly seen on the beach, cast up after a storm, grow in abundance in localities within the five-mile limit. Certain crabs (Persephona, Hepatus) and starfish (Astropecten, Luidia) may especially be mentioned as conspicuous examples. The beach collecting after a southerly blow is often good. Quantities of anemones (Paractis), holothurians, compound ascidians, sponges, and stranded jellyfish are to be had.

The wharf piles at Morehead City (railroad terminus) and Beaufort, and the stone jetties on each side of the inlet deserve to be mentioned. They are among the best collecting places for attached forms — algæ, hydroids, sponges, polyzoa, anemones. Beaufort is a capital place for the study of pelagic types. A strong tide sets into the harbor, bringing a great variety of hydromedusæ, Entomostraca, pelagic worms, and a wealth of larval forms. Certain interesting Protozoa (Acanthometra, Noctiluca) are very abundant. The proximity of the gulf stream (the 100-fathom line, which marks the western bank of the stream,[1] is some fifty miles distant) frequently leads to the presence in the harbor of many forms character-

[1] Agassiz. *Three Cruises of the "Blake,"* vol. i, p. 257.

istic of more southern waters. These forms often appear in large numbers, and many remain for weeks. Among such may be mentioned Physalia, Porpita (Professor Brooks mentions[1] that he has here taken nearly all the siphonophores known to occur on the Atlantic coast), the rhizostomous medusa Stomolophus, the pelagic annelid Amphinome. On a calm evening in Beaufort harbor, with a flood tide, it is best to abandon the tow net for the dip net. The individuals are abundant enough to make the use of the latter successful, and the perfect condition in which delicate forms, such as Diphyes, Lucifer, Cuninas, Phyllosoma larvæ, etc., may thus be taken repays for the time spent.

Beaufort itself is a quaint and attractive town, with its wide, grassy lanes, and inclining trees (live oaks, mulberries, elms), which show plainly the direction of the prevailing wind. Viewed from the harbor the town presents a long line of white houses that edge the shore, each with its upper and lower porch, from which (more especially the upper) the harbor in turn offers a very pleasing picture. In the late afternoon, when the glare has become less intense, the picture is one that stays in the memory as a restful composition of sky and water, the latter broken here and there with green marsh islands and white shoals, with sand dunes on the banks and breakers in the inlet shutting in the view. To the eastward big reels, on which seines are wound, make a detail suggestive of the village life.

The climate is equable, but cold comes occasionally, as in last February, when the fig trees were killed to the ground. The summer temperature is not unpleasant, though one's workroom should be a large, airy one close to the shore ("on the town front," as the saying is) and open to the sea breeze. I have before me a record of temperatures made by Professor E. A. Andrews during the warmer part of the year. The observations were taken at 7 A.M and 9 P.M. daily. During May the temperature at these times was, day after day, 74°–75°. In June there were some cold days, the thermometer going down to 66°, the weather growing warmer, though, in the latter part of the month, when 78°–79° was reached. Dur-

[1] *Report of the President of the Johns Hopkins University*, p. 82, 1883.

FIG. 2.—BEAUFORT—A PART OF THE "TOWN FRONT."

(The photographs made use of in the preparation of this article have been kindly loaned by Professor J. I. Hamaker.)

FIG. 3.—EAST END OF BEAUFORT—THE TOWN SHORE.

ing July and August the temperature on many days was 79°–81°, rarely going a degree or two above that, and much more frequently dropping several degrees below. In September the weather was cooler, the range being from 67° to 80°. At midday a very common summer temperature is 85° — only occasionally (at the times when 100°–105° is registered for so many of the cities) is it warmer. During the past season the laboratory was comfortable day and night, save once in June, when the heat of the lamps made microscopic work trying.

With proper precautions Beaufort is a healthful as well as a pleasant summering place for most people. Morehead City, across the harbor, is a well-known resort in this part of the South, and many people come also to Beaufort. The fishing, sailing, and the daily bath make the days pass agreeably for those who have nothing else to do, and contribute much to the *bien-être* of naturalists who are spending a working vacation. The ocean beach is a hard, fine one, and the surf bathing about like that of the better known Jersey coast. For the regular daily bath, however, most people prefer the harbor. With a skiff, in five minutes, one reaches a clean sand shoal, over which the ocean water is flowing from the inlet opposite, and with the first plunge becomes aware of the pleasure that lies in this part of the day's routine.

This is not the place for a catalogue of the Beaufort fauna and flora. And, indeed, many as are the forms known to occur here, which have been identified, much systematic work will be necessary before they can all properly be listed. Moreover, forms hitherto not known to occur here are discovered often in abundance with every season of work. The more important published lists of Beaufort forms are contained in the following papers:

Wm. Stimpson, M.D. "A Trip to Beaufort, N. C.," *Amer. Journ. of Sci.*, Series 2, Vol. XXIX, 1860. The paper contains lists of ascidians, mollusks, and decapod Crustacea. The Lingula of the south Atlantic coast is here first described, although McCrady, writing shortly after from Charleston (*Amer. Journ. Sci.*, Vol. XXX), mentions that it "was found more than ten years ago on our coast by the Rev. Thomas J.

Young," and that Professor Louis Agassiz, at his laboratory in Charleston harbor, had had specimens. McCrady was, I believe, the first to observe Lingula larvæ, since described in Professor Brooks's well-known paper and taken in Beaufort harbor, both by Professor Brooks and (during the past season) by Professor J. Y. Graham.

Coues and Yarrow, "Notes on the Natural History of Fort Macon, North Carolina, and Vicinity" (Nos. 1–3), *Proc. Acad. Nat. Sci. Phila.*, 1871, 1877. The vertebrate lists are much more complete than the invertebrate. There are recorded 24 mammals, 133 birds, 27 reptiles, 6 amphibia, 111 fishes. Of the invertebrates recorded the only list approaching completeness is that of the mollusks (147).

A. E. Verrill, "On Radiata from the Coast of North Carolina," *Amer. Journ. Sci.*, 1872. This paper includes lists of cœlenterates and echinoderms (Coues and Yarrow's Collection).

A. E. Verrill, "Notes on Natural History of Fort Macon" (Coues and Yarrow's Collection of Annelids), *Proc. Acad. Nat. Sci. Phila.*, 1878.

J. S. Kingsley, "On a Collection of Crustacea from Virginia, North Carolina, and Florida," etc., *Proc. Acad. Nat. Sci. Phila.*, 1879.

J. S. Kingsley, "List of Decapod Crustacea of the Atlantic Coast," whose range embraces Fort Macon, *Proc. Acad. Nat. Sci. Phila.*, 1878.

In these two papers of Kingsley's there are recorded over sixty decapods for Beaufort harbor.

Jordan and Gilbert, "Notes on Fishes of Beaufort Harbor, North Carolina," *Proc. U. S. Nat. Mus.*, 1878.

E. A. Andrews, "Report upon the Annelida polychæta of Beaufort, North Carolina," *Proc. U. S. Nat. Mus.*, Vol. XIV, 1891.

Many of the Beaufort forms have been first described by some of the older naturalists, whose collections were made farther south, along the coasts of South Carolina, Georgia, and Florida. Among such may be especially mentioned Catesby[1],

[1] Natural History of Carolina, Florida, and the Bahama Islands.

Bosc[1], Say[2], Le Sueur[3], Louis Agassiz[4], Gibbes[5], Stimpson[6], McCrady[7]. Other forms are constantly met with, which were first described by naturalists working farther north, on the Virginian coast (H. E. Webster)[8], on the coasts of Rhode Island and New Jersey (Leidy)[9], coast of New York (De Kay)[10], New England coast (Verrill[11], Verrill and Smith[12], Gould and Binney[13]). Other well-known memoirs, which are especially useful for systematic work at Beaufort are: Alexander Agassiz's "North American Acalephæ"[14]; Verrill's "Revision of the Polypi of the Eastern Coast of the United States"[15]; the various reports on the results of dredging, under the supervision of Alexander Agassiz, by the U. S. Coast Survey Steamer *Blake* (published in the *Memoirs* and *Bulletin* of the Museum of Comparative Zoölogy); Dall's "Catalogue of Mollusks and Brachiopods of Southeastern Coast of United States."[16]

In the *Studies from the Biological Laboratory of the Johns*

[1] Hist. Nat. des Crustacés; Hist. Nat. des Vers.

[2] An Account of the Crustacea of the United States, *Journ. Acad. Nat. Sci. Phila.*, vol. i, 1817–18, *The Complete Writings of Thomas Say on the Conchology of the United States*, edited by Wm. G. Binney, 1858.

[3] Observations on Several Species of the Genus Actinia, *Journ. Acad. Nat. Sci. Phila.*, vol. i, 1817–18.

[4] Contributions to the Natural History of the United States.

[5] On the Carcinological Collections of the United States, and descriptions of new species, *Proc. Amer. Ass. Adv. Sci.*, vol. iii, 1850.

[6] Notes on North American Crustacea, *Ann. Lyceum Nat. Hist. of N. Y.*, vol. vii, 1862. On Some Remarkable Marine Invertebrates inhabiting the Shores of South Carolina, *Proc. Bost. Soc. Nat. Hist.*, vol. v, 1856.

[7] Gymnophthalmata of Charleston Harbor, *Proc. Elliott Soc. Charleston*, vol. i, 1853–58.

[8] Annelida chætopoda of the Virginian Coast.

[9] Marine Invertebrate Fauna of Coasts of Rhode Island and New Jersey, *Journ. Acad. Sci. Phila.*, vol. iii, 1855.

[10] *The Natural History of New York*, Pt. i, Zoölogy. The volume on Mollusca and Crustacea is particularly useful to the collector, because of its condensed descriptions of "extra limital" forms.

[11] *New England Annelida*, Pt. i, 1881.

[12] *Report on Invertebrate Animals of Vineyard Sound*, 1873.

[13] *Report on the Invertebrata of Massachusetts*, 2d ed.

[14] *Illust. Cat. of Mus. of Comp. Zoölogy*, 1865.

[15] *Mem. Bost. Soc. Nat. Hist.*, vol. 1, 1866–69.

[16] *Bull. U. S. Nat. Mus.*, *No. 37*, 1889.

Fig. 4. — To the East of Beaufort — Shackelford Bank in the Distance.

Fig. 5. — Sand Dune on Shackelford Bank.

Hopkins University, and in the *Johns Hopkins University Circular*, from 1880 on, naturalists working at Beaufort will find many papers and notes of faunistic interest, in which new forms are described or known ones recorded. Among these may be mentioned Professor Brooks's papers on "Medusæ" (*Studies*, 1882, 1883); and the lists and notes by Professors McMurrich (Actiniæ), Osborne (Mollusca), Nachtrieb (echinoderms), Jenkins (fishes), collected together under the title "Notes on the Fauna of Beaufort, N. C." (*Studies*, 1887). A great many facts of general natural history interest (systematic, distributional, ecological) will also be found scattered through the pages of the morphological and embryological memoirs which have been appearing since 1880 as the result of the work of Professor Brooks and his students at Beaufort.

At the laboratory of the U. S. Fish Commission, which was maintained during the past summer at Beaufort, the various species observed were recorded, and specimens preserved for the museum collection of the laboratory. It is planned that the record of each species shall include mention of the localities in which it is fairly abundant, most convenient collecting methods, time of year during which breeding goes on, brief natural history notes on habits of adult (food, enemies, parasites, rate of growth, time and extent of migration, etc.) and on the life history (character of eggs, where and how deposited, possibility of artificial fertilization, period of embryonic development, character of larva and period of larval development, habitat, food and enemies of larva). The economic value of such a knowledge of the natural history of the region will be readily understood, and it is equally obvious to what an extent it will aid naturalists engaged in the study of the abstruse problems of morphological and physiological embryology, of comparative anatomy and physiology. Its value in connection with similar results of the work at other coast stations, to the study of the variability of organisms, may be here alluded to.

To carry out such a scheme of work for a rich fauna like that of Beaufort will require years. An excellent basis has, however, been built up, and profitable lines of study marked out by the members of the Johns Hopkins Marine Laboratory and by

other naturalists. During the past season's work (1899) of the Fish Commission Laboratory many of the previously known facts, some recorded, some unrecorded (in the possession of former workers at Beaufort), have been brought together and confirmed, and important additions have been made. The forms actually collected during the season included 238 species of marine invertebrates, some 70 fishes, 50 birds, a number of reptiles, amphibia, insects and arachnoids, and a very considerable number of land plants and algæ. In the case of a good number of species, notes along the lines indicated above were made. In gathering the data of the record all members of the laboratory lent their assistance, during such time as they were able to spare from their special investigations. I would especially thank Professors W. K. Brooks, E. W. Berger, J. Y. Graham, J. I. Hamaker, T. G. Pearson, Dr. D. S. Johnson, Dr. G. A. Drew, and Dr. Caswell Grave. Identifications and notes on breeding times have also been very kindly contributed by Professors E. A. Andrews, C. B. Davenport, J. S. Kingsley, George Lefevre, M. M. Metcalf, J. P. McMurrich, E. B. Wilson. In another season's work, doubtless, all the recorded forms will have been taken and identified. Further progress can only be made by a formal division of labor among the members of the laboratory. With the great awakening of interest, which is so apparent to-day, in the phenomena exhibited by animals and plants regarded as living units, it should not be difficult to find naturalists who will gladly work up the local natural history of the groups embracing the particular forms on which they may be investigating problems of a morphological or physiological character.

From among the forms occurring at Beaufort the following common summer ones may be selected with the purpose of giving a conspectus of the local fauna and flora. The months given immediately after the name of each species are breeding months, but it is not implied that breeding is limited to these months. In many forms breeding undoubtedly continues through a large part of the year — oyster eggs, for instance, have been fertilized in December by Dr. Caswell Grave. With a few exceptions the forms listed were noted during the past

season. The exceptions include forms recorded by myself in 1886, 1894, 1898.

Protozoa. — *Noctiluca miliaris* and Acanthometra *sp.* are abundant in the tow throughout summer.

Sponges. — *Chalina arbuscula, Microciona prolifera, Cliona sulphurea,* and several other monactinellid sponges are common. No eggs nor gemmules have been observed during the earlier summer months, but by September 1st a number of species are breeding.

Cœlenterates.

Hydrozoa. — Hydroids: *Hydractinia echinata,* with gonophores, June; *Eudendrium ramosum,* with gonophores, June; *Sertularia carolinensis* (*sp.* ?), with gonothecæ, June; *Aglaophenia trifida;* Campanularia *sp.; Parypha cristata,* with gonophores, June, July. Hydromedusæ: *Liriope scutigera,* July, August; *Nemopsis bachei,* July, August; *Cunoctantha octonaria,* adults and parasitic larvæ, July, August; Cunina *sp.*, parasitic larvæ in Liriope, August; *Turritopsis nutricula,* July, August; *Margelis carolinensis; Eutima mira.* Siphonophores: Diphyes *sp.*, *Physalia arethusa, Porpita linnæana.*

Scyphomedusæ. — *Stomolophus meleagris, Chiropsalmus quadrumanus, Dactylometra quinquecirra, Cyanea versicolor* (*sp.* ?). Ephyra larvæ (*sp.* ?), common in tow, July, August.

Actiniaria and Madreporaria. — *Paractis rapiformis, Aulactinia capitata, Adamsia sol, Aiptasia pallida, Cerianthus americanus, Astrangia danæ,* Oculina *sp.* Arachnactis larvæ, in tow, August.

Alcyonaria. — *Renilla reniformis,* May, June, July; *Leptogorgia virgulata,* May, June, July; *Rhipidogorgia flabellum.*

Ctenophora. — *Mnemiopsis gardeni.*

Echinoderms. — Starfishes: *Asterias arenicola,* April; *Luidia clathrata,* August; *Astropecten articulatus,* August; large bipinnarias with budding starfish in tow, July. Ophiuroids: Amphiura *sp.*, June, larva a pluteus (species dredged three to nine fathoms, outside inlet); *Ophiura brevispina,* July, August, eggs discharged shortly after nightfall; *Ophiothrix angulata* (*sp.* ?), June, July; *Ophiolepis elegans,* nine fathoms, outside inlet, eggs nearly mature July 12. Echinoids: *Arbacia punctulata,*

June, July; *Toxopneustes variegatus*, June, July; *Moira atropos*, August; *Mellita testudinata*, early September. Holothurians: Thyone briareus; *Leptosynapta girardii* (*sp.*?), with apparently mature eggs, July; small synaptas abundant in night tow, August.

Worms. — Annelids: *Amphitrite ornata*, June; *Petaloproctus socialis*; Notomastus *sp.*; *Marphysa sanguinea*; *Diopatra cuprea*; *D. magna*, egg mass containing larvæ, July; *Nereis limbata*, September; *Hydroides dianthus*, July; *Harmothoe aculeata*; *Axiothea mucosa*, June, July; *Arabella opalina*; *Loimia turgida*; *Arenicola cristata*, June to August; *Sabella microphthalma*; *Pectinaria gouldii*; *Sabellaria vulgaris*, July; *Autolytus cornutus*, August, September (in tow); *Procerœa ornata*; *P. tardigrada*, early September (night tow); *Rhyncobolus americanus*; *Chætopterus pergamentaceus*, June to August; *Sthenalais picta*. The interesting pelagic form, *Amphinome pallasii* (one of the *Blake* species), appeared in the harbor July 18; eggs and sperm were freely discharged. Other "worms": *Bdelloura candida*, June; *Meckelia rosea* (*sp.*?); *Cerebratulus ingens*; Sagitta *sp.*, June to September; *Thalassema mellita*, June; *Balanoglossus brooksii*, *B. kowalevskii* (*sp.*?). Professor Andrews in 1885 discovered the presence of the interesting form Phoronis (*P. architecta* Andr.). Actinotrocha larvæ are common in the tow during summer.

Mollusca. — In Stimpson's list (*loc. cit.*, 1860) 174 mollusks are recorded. Coues and Yarrow (*loc. cit.*) again list most of these and record a few others. Osborn (*loc. cit.*) records still others. The following may be mentioned:

Lamellibranchs: *Venus rugosa* (*sp.*?) June, the burrowing form *Lithodomus lithophagus*, *Cytherea gigantea*, *Dosinia discus*, *Moctra solidissima*, *Tagelus gibbus*, *T. divisus*, *Modiola plicatula*, Pholas *sp.* (small species found in rotten wood; shells of *P. costata* common), *Solenomya velum*, *Anomia glabra*, *Arca transversa*, *A. ponderosa*, *A. pexata*, *Cyclas dentata*, *Cardium magnum*, *Pecten dislocatus*, *Donax fossor*, *Tellina alternata*, *Ostrea virginiana*, *Xylotria fimbriata* (and other shipworms) August, *Pinna semi-nuda*, Lima *sp.*, *Venus mercenaria*, *Roccellaria stimpsoni*.

Gastropods. — *Fulgur carica*, June, July; *F. canaliculata*; *Neverita duplicata*, June, July; *Sigaretus perspectivus*; *Purpura hæmastoma*, eggs deposited in confinement, July; *Strombus alatus*; *Fasciolaria tulipa*, June, July; *Crepidula fornicata*, June; *C. plana*, June; *Ilyonassa obsoleta*; *Urosalpinx cinerea*, June; *Oliva literata*; *Ovulum uniplicatum*; *Fissurella alternata*; *Littorina irrorata*; *Chætopleura apiculata*.

Among the opisthobranchs, species of Aphysia, Æolis, Doris, Polycera, Scyllæa (on gulf weed), Ancula, occur. Among the pteropods, *Styliola vitrea* is occasionally abundant. Among the cephalopods, *Loligo pealii* is rarely taken, and a form of lighter color (*sp.*?) more commonly. Squid eggs are frequently dredged during summer, outside the inlet.

Crustacea. — As has been mentioned, something over sixty decapods are recorded for the locality. Beaufort is far enough to the south for the crab fauna, in particular, to show something of that variety, which becomes so pronounced in the tropics.

Decapods. — *Panopeus herbstii*, June, July; *Lupa sayi*, July; *Sesarma reticulata*; *Menippe mercenaria* ("stone crab"); *Callinectes hastatus*, June; *Ocypoda arenaria*; *Libinia canaliculata*; *Hepatus decorus*; *Gelasimus pugnax*; *Persephona punctata*, September; *Platyonichus ocellatus*; *Porcellana ocellata*, September; *P. macrocheles*, July, August (commensal in Chætopterus tubes); *Pinnotheres ostreum*; *Pinnixa chætopterana*, August (a rarer commensal in Chætopterus tubes); *Hippa emerita*; *Eupagurus vittatus*, June; *E. longicarpus*; *E. pollicaris*; *Penæus setiferus* (sold during latter part of August and September); *Palæmonetes vulgaris*, July; *Alpheus heterochelis*, July to September; *Alpheus minus*, September; *Gebia affinis*, June; *Tozeuma carolinensis*, August; Lucifer *sp.*, summer. The taking of the curious "false hermit" (*Hypoconcha arcuata*) may be referred to — the form has been recorded by Stimpson from South Carolina.

Among the forms belonging to other groups of Crustacea may be mentioned: *Squilla empusa*, *Lysiosquilla excavatrix*, Diastylis *sp.* (this cumacean is regularly taken in the night tow throughout summer); a large isopod (Ligia *sp.*), very abundant

on wharves; an isopod (Gyge *sp.*), parasitic in branchial cavity of *Alpheus heterochelis;* another parasitic isopod (*Livoneca ovalis*, with embryos in August), common on gills of pinfish; Orchestia *sp.*; Caprella *sp.*, June. Numerous copepods and cladocera, many with eggs or embryos, are constantly taken in the tow throughout summer.

Among the cirripeds may be mentioned the common rock barnacle and ivory barnacle (*Balanus eburneus*), *Lepas anatifera*, which frequently appears in the harbor; a small Lepadide (Dichelaspis *sp.*), a common parasitic form on the gills of the edible crab, with abundant eggs in July, — this interesting form is probably the species mentioned by Fritz Müller (*Facts for Darwin*, p. 137) as occurring at Desterro on same crab (*Lupa diacantha*), — it differs in specific points from the several other members of the genus, described by Darwin and Hoek (*Challenger* Report). Limulus is of course abundant, young specimens swarming on the sand shoals in early summer (June). The eggs of Limulus were, as far as I know, for the first time artificially fertilized in 1882 by Professor H. L. Osborn at Professor Brooks's laboratory here.

Naturally but little attention has been paid to the tracheate arthropods — enough though to show that the locality is an excellent one for these groups. A few characteristic forms are: the slender, long-legged myriapod *Cermatia forceps*, sphinx moth, *Phlegethontius carolina* (larva, "tomato-worm," excellent for anatomical work and for metamorphosis), rhinoceros beetle, *Dynastes tityrus*. One of the large hunting spiders, Lysosa *sp.* (carrying cocoon in early September), is abundant. The cow-killer ant (burrowing mutillid wasp, female wingless), *Sphærophthalma sp.*, is a common form.

The polyzoa have not been studied. The common forms are species of Vesicularia, Bugula, Membranipora, Escharella, Pedicellina (species with spines, probably *P. echinata*). The only brachiopod known here, *Lingula pyramidata*, and its larva have already been spoken of. The particular locality in the harbor (first mentioned by Coues, *loc. cit.*) where Lingula, associated with Renilla and Amphioxus, was extremely abundant some years ago, has been encroached upon by a growing

shoal and is no longer a good collecting place. Some equally good spots may in time be located.

The tunicates, too, are badly in need of systematic work. A large ascidian, Styela *sp.* (doubtless the *Cynthia vittata* of Stimpson's list), two to three inches high, is extremely abundant on the sand shoals and wharf piles. Another large and translucent form, Ascidia *sp.*, is fairly abundant on wharf piles and old shells, breeding in May and June. *Molgula manhattensis*, *Perophora viridis* (breeding in June and July), Amarœcium *sp.* are common species. Appendicularia *sp.* is a common form in the tow throughout summer — Professor George Lefevre has found it breeding from April to August. Doliolum *sp.* is occasionally taken in the harbor through the summer — both the nurse with stolon and buds, and the sexual form with ripe eggs.

The variety of fishes that may be taken in a short time in Beaufort harbor and adjoining waters is so great as to make it evident that the number recorded (Jenkins, *loc. cit.*, gives 134) for the region will be greatly increased when systematic collecting has been carried on for a few years. Some nine miles from Beaufort inlet the coast line makes a sharp, right-angled bend, with Cape Lookout at the angle. From the end of the cape a narrow line of shoals extends much farther out. The cape and its submerged continuation form a wall, as it were, reaching seaward for fifteen miles. Cape Lookout itself is so shaped as to embrace a bay, a quiet and beautiful sheet of water, Lookout Bight. The coast configuration thus forms a remarkable natural trap into which fish, migrating northwards, fall. It is doubtful whether a better place can be found anywhere on our coast for the carrying out of observations on oceanic species and on bay and river species during the oceanic period of their life. The seining that has been carried on at Cape Lookout has been extremely interesting and successful, both as regards the variety of forms and the number of individuals taken.

The following species may be mentioned from the harbor and adjacent waters: Amphioxus is found, but is not common — the pelagic larvæ are taken in the tow (July). The com-

monest sharks are the "sharp-nosed," *Carcharinus terræ-novæ*, "shovel-headed," *Sphyrna tiburo*. Young "hammerheads," *Sphyrna zygæna*, are very abundant in the early summer in some years. The sawfish, *Pristis pectinatus*, is frequently taken. The sting ray, *Trygon sayi*, and butterfly skate, *Pteroplatea maclura*, are abundant. Several eagle rays are occasionally taken (cow-nosed ray, *Rhinoptera quadriloba*, last summer), and the sea devil, *Manta birostris*, has been caught at Cape Lookout. Several cyprinodons (Fundulus, Cyprinodon, Gambusia) are abundant alongshore and in "salt ponds" — *F. heteroclitus*, with ripe eggs, July. Blennies are abundant about the wharf piles, *Hypleurochilus multifilis* depositing its eggs on sponges, etc., August. The toadfish, *Batrachus tau*, and its eggs (summer) are of course abundant. *Selene vomer* and some other "moonfishes," two halfbeaks (*Hemirhamphus braziliensis*, *H. unifasciatus*), the shark pilot, *Echeneis naucrates*, pipefish, *Siphostoma floridæ*, and *Hippocampus hudsonius*, *Nomeus gronovii* (in bell cavity of the rhizostomous medusa, Stomolophus), several swellfishes (*Logocephalus lævigatus*, *Chilomycterus geometricus*, *Tetrodon turgidus*) may be referred to. The commonest summer food fishes are the bluefish, Spanish mackerel, sheepshead, jumping mullet, sea mullet, hogfish (*Orthopristis chrysopterus*), pinfish (*Diplodus rhomboides*), croaker, spot, porgee, weakfishes (local "trouts," *Cynoscion regale*, *C. maculatum*), "blackfish" (*Serranus atrarius*), a number of flounders (flounder spearing with a torch of "fat" pine is a common occupation on summer nights). The menhaden (local "fatback") fishery is an important industry. Some attention was paid during the past season to the breeding condition of the edible species, and June would seem to be a good month for fish-cultural work — the hogfish, porgee, and sea mullet are breeding at that time.

Birds. — The laboratory is indebted to Professor T. G. Pearson, of Guilford College, for the identification of some fifty summer birds. Gulls and terns are uncommon in the harbor. In the salt marshes several herons are abundant, also the clapper rail and the marsh wren (Worthington's), the interesting false nests of which are easily found. The Florida

cormorant is frequently seen flying across the harbor. Characteristic shorebirds are the black-bellied plover, oyster catcher, willet, spotted sandpiper, yellow legs. Other characteristic birds seen about the harbor are the fish crow and boat-tailed grackle. In the town, and in the woods back of the town, and on the banks, many species are found which are common in the central part of the state (mourning dove, flicker, kingbird, crested flycatcher, phœbe, towhee, cardinal, mocking bird, brown thrasher, titmouse, Carolina chickadee). In the winter there is said to be good duck shooting in the neighborhood of the town.

Other Vertebrates. — A number of lizards are abundant in and back of the town (*Anolis carolinensis*, *Eumeces fasciatus*, *Cnemidophorus sexlineatus*, *Sceloporus undulatus*). Alligators are said to be common in localities close to Beaufort, especially in White Oak River, opening into Bogue Sound. Specimens are occasionally brought into Beaufort. The bank ponies quickly attract the attention of the newcomer. They run wild on the banks and adjacent parts of the mainland, and are periodically corralled ("penned") for branding and sale. The ponies are fond of the salt-marsh grass, and droves may, on almost any day, be seen wading or swimming between the shore and the marsh islands. Deer are fairly abundant in localities, both on mainland and banks. Other common mammals are the mink, raccoon, opossum. Coues (*loc. cit.*) says the "marsh hare" (*Lepus palustris*) is "the most abundant and characteristic mammal" on Bogue bank. Porpoises are frequently seen in the harbor; the pairing season, according to Coues, is in April and May.

Dr. D. S. Johnson and Mr. W. C. Coker, of Johns Hopkins University, made, during the past season, a reconnaissance of the flora of the region, the results of which Dr. Johnson has embodied in two papers (on the flora of the banks, and the algæ of the harbor), which will appear in the Fish Commission publications. Dr. Johnson describes the peculiar physiographic characteristics of the banks, which (I quote from his unpublished paper) "vary in width from a quarter of a mile to a mile and a half, and in height from nearly sea-level, in the case of

certain fresh water and salt marshes, to a maximum height of perhaps forty feet in the case of some of the wind-blown dunes. The conditions prevailing on the higher parts of these banks are quite peculiar, in that while the shifting sandy soil holds very little water, yet the air is very damp, since during the growing season the prevailing wind is a strong sea breeze saturated with moisture. Thus are to be explained, perhaps, the frequent occurrence in this very dry soil of many plants which usually occupy a much damper soil, and the striking abundance of epiphytic lichens, liverworts, mosses, and ferns." While the algal flora is not so varied as on more rocky parts of the coast, a very considerable number of species are present in abundance. Among these may be mentioned *Hypnea musciformis*, *Ulva lactuca*, *Dictyota dichotoma*, *Rhabdonia tenera*, *Gracilaria confervoides*, *Codium tomentosum*, *Padina pavonia*, *Sargassum vulgare*, *Dasya elegans*, *Melobesia pustulata*, and species of Callithamnion, Ectocarpus, Enteromorpha, and Polysiphonia.

With its rich and accessible fauna it is not to be wondered at that Beaufort should have been so attractive to naturalists. Among those who carried on investigations in this locality before 1880 may be mentioned Professor Louis Agassiz, Dr. Stimpson, Dr. Gill, Dr. Coues, Dr. Yarrow, President Jordan, Professor Morse, Professor Packard, Professor Webster. In 1880 the marine laboratory of the Johns Hopkins University, which during the previous two years had been located at points in the Chesapeake Bay, was stationed here. A large house near the extreme eastern end of the town was rented continuously, and an excellent equipment, including a 47-foot sloop and a steam launch, was provided. Professor Brooks, with his students and co-workers, continued their investigations year after year at Beaufort (with the exception of 1883, when the laboratory was stationed at Hampton, Va.) until 1886, when they spent the summer in the Bahama Islands. During most of the years since that time the Johns Hopkins laboratory has been stationed in the Bahamas or in Jamaica, with returns to Beaufort at intervals. The important share which this laboratory has had, since its inauguration in 1878 at Fort Wool, in

determining the character of zoölogical study in America is well known. A list of its members will be found to include many of the leaders in this branch of science in the several parts of the country, and the number of memoirs and papers based on observations made during its sessions is very large.

During the last few years there have been in Beaufort, from time to time, parties of naturalists from Columbia (under Professor E. B. Wilson) and other universities, as well as from the Johns Hopkins. The U. S. Fish Commission has for years been familiar with the fact that Beaufort presented many opportunities for the scientific study of economic problems. The large number of edible fish and Crustacea, the extensive beds of clams and oysters, make the region one of commercial importance. At Professor Brooks's laboratory many contributions to the life histories of edible forms (shrimps, crabs, fish, oyster) were made. As a continuation, along economic lines, of Professor Brooks's discoveries concerning the development of the American oyster, Lieutenant Winslow's experiments on the artificial propagation of oysters may be mentioned. Professor Brooks, Lieutenant Winslow, Professor H. L. Osborn have all pointed out what an abundant "set" of spat may be had, and how rapidly the spat grows. An extensive survey of the oyster grounds of North Carolina was carried out some years ago, under the direction of Lieutenant Winslow;[1] and the U. S. Fish Commission, conjointly with the director of the Geological and Natural History Survey of North Carolina, Professor J. A. Holmes, has had in progress since last September a reëxamination of a part of the ground, with especial reference to the present condition of planted beds. As an outcome of this work we may expect to have, in the near neighborhood of Beaufort, a carefully planned and conducted experimental oyster farm, on which a continuous series of observations may be carried out for some years, with the sure expectation that improvements in oyster culture will result.

[1] Winslow, Lieutenant Francis. Report on the Waters of North Carolina, with reference to their possibilities for oyster culture, *State Printer*. Raleigh, 1886; Report on the Sounds and Estuaries of North Carolina, with reference to oyster culture, *U. S. Coast and Geodetic Survey, Bulletin No. 10*, 1889.

A year ago the director of the Geological Natural History Survey of North Carolina represented to the U. S. Commissioner of Fish and Fisheries, Hon. George M. Bowers, how desirable it was for the material development of the marine fisheries that some step be taken toward providing a headquarters, where continuous observations might be made on the natural history of the fauna of the south Atlantic coast, and how suitable the town of Beaufort was for such a purpose. In May Dr. H. M. Smith, in charge of the Division of Scientific Inquiry, announced (*Science*, Vol. IX, No. 227) the decision of the Commission to maintain, during the summer, at Beaufort, a laboratory for the prosecution of researches in marine biology. A suitable building was rented, and a proper equipment, including small boats, steam launch, dredges, trawl, etc., was provided. The laboratory was occupied from June 1 to September 15. A dozen naturalists were there, representing the Johns Hopkins University, University of Alabama, Baldwin University, Trinity College (N. C.), Guilford College, University of North Carolina. Mention has already been made of the fact that, in addition to the individual research work, considerable attention was paid to the accumulation of data on the local habitat, breeding times, etc., of the more abundant species of the region. The laboratory building is rented continuously, and the equipment and collections are stored there. The laboratory will reopen for work in June. As at Woods Holl, no charge is made to the occupants of tables.

While the temporary laboratory now organized at Beaufort answers many needs, it is greatly to be desired that a permanent Fish Commission station be established there. A bill providing the necessary appropriation for such a station is now before Congress. The policy of maintaining Fish Commission stations, at which ample opportunity is offered for scientific investigation, has been fully justified by the history of the station at Woods Holl. The results of the purely voluntary researches of the naturalists who have annually visited this station are of the highest value. In no way can the Fish Commission accumulate useful information concerning the animal and plant life of a region, so rapidly and at so little

expense, as by maintaining a well-equipped laboratory, open to all who come to study the natural history of that region. Professor Alexander Agassiz, in his report on the Museum of Comparative Zoölogy for the year 1894–95, points out the mutual advantages that result from coöperation between the Fish Commission and those engaged in research work in biology. Mr. Agassiz has especially in mind the Woods Holl station, but his remarks have a wider applicability. Mr. Agassiz remarks that "no university laboratory can hope to obtain the facilities accruing from the maintenance of the fleet of small boats and steamers, and of the personnel which forms a necessary part of the equipment of the Fish Commission Station"; and farther on: "The mere collecting of material for ordinary investigation, at a marine station, is not expensive, but it is expensive to carry on the continuous observations of eminent specialists, and subsequently to publish their investigations. *Such observations could well be carried on in connection with the work of a Government Fish Commission, and are not only germane to its investigations, but all important to their success.*"[1]

The bill providing for a marine station at Beaufort has the earnest support of many naturalists and college presidents in the North, West, and South. It is widely recognized how advisable, both from the scientific and economic standpoint, it is to have several stations along our coast at which observations may be carried on year after year. The wisdom of such a course becomes manifest when we consider the length of the coast, the difference in the character of its fauna at widely separated places, and the migratory habits of many animals (food fishes, etc.). It may safely be said that many of the most interesting economic problems, such, for instance, as the effect of the feeding ground on edible animals, and the possibility of altering such grounds, can only be solved after a comparison of results, obtained at various points on the coast, has been made, and the same is true for the broader study of variation in its strictly scientific aspect.

University of North Carolina.

[1] Italics are mine.

THE FRUITING OF THE BLUE FLAG (IRIS VERSICOLOR L.).

JAMES G. NEEDHAM.

At the time of the adjournment of my college classes last June, I spent a few hours afield, watching the blue flags and their insect visitors, at first solely for the pleasant recreation that such study affords. But I soon made a few enticing little discoveries which set me to work in earnest. I began by locating all the clumps that were easy of access from my home in Lake Forest, and then I studied them daily during the flowering season, and almost daily thereafter throughout the summer.

The facts that first caught my attention were: (1) that there are many visitors to these flowers that seem to have been unnoticed hitherto; (2) that most of these are illicit visitors; and (3) that the ill-adapted ones are habitually deceived by the flower itself as to its proper entrance. I propose to give in the following pages the more important results of the season's observations.

It seemed to me that any new study of this so familiar flower should be undertaken on somewhat broader lines than are usually followed. The reproductive phase of the plant is a unit, and the flower is but one of a series of devices for furthering the reproductive process. Bud and flower and capsule and seed are the successive centers of interdependent ecological phenomena, determining the start in life of the next generation. I have tried to study the effect of insects upon the outcome of the reproductive process as a whole, and I discuss, below the chief ecological relations under the following headings: Pollination; The Waste of the Nectar; The Destruction of the Flowers; Fertilization; The Destruction of the Seeds; Inflorescence, and Chances of Maturing Fruit; The Relation of Habitat to Fertility; Alteration of Environment.

I. Pollination.

The flowers of the Iris have long been known to be entirely dependent on insects for the transference of their pollen. The structure of the flower has so often been described, there is no need of describing it again; if the reader has forgotten, he may refresh his memory by reference to the accompanying figures. He will recall a flower divided into three parts, requiring three separate visits by the insect which would obtain its stores; in each part an extrorse anther placed with its back against an overarching branch of the extremely large, three-parted style (Fig. 1, *R*); below anther and style a passage-way to the nectary, with the usual guide streaks at its entrance, is formed by the channeled sepal. The stigma is restricted to the upper surface of an inferior, transverse, flap-like appendage of the style branch, just beyond the apex of the anther (Fig. 2). This flap is very thin and remains appressed to the style, with its free border toward the entrance, the stigmatic surface covered. The pollen-laden back of an entering insect, rubbing against it, readily everts the flap and deposits pollen on the stigmatic surface. Released, it closes

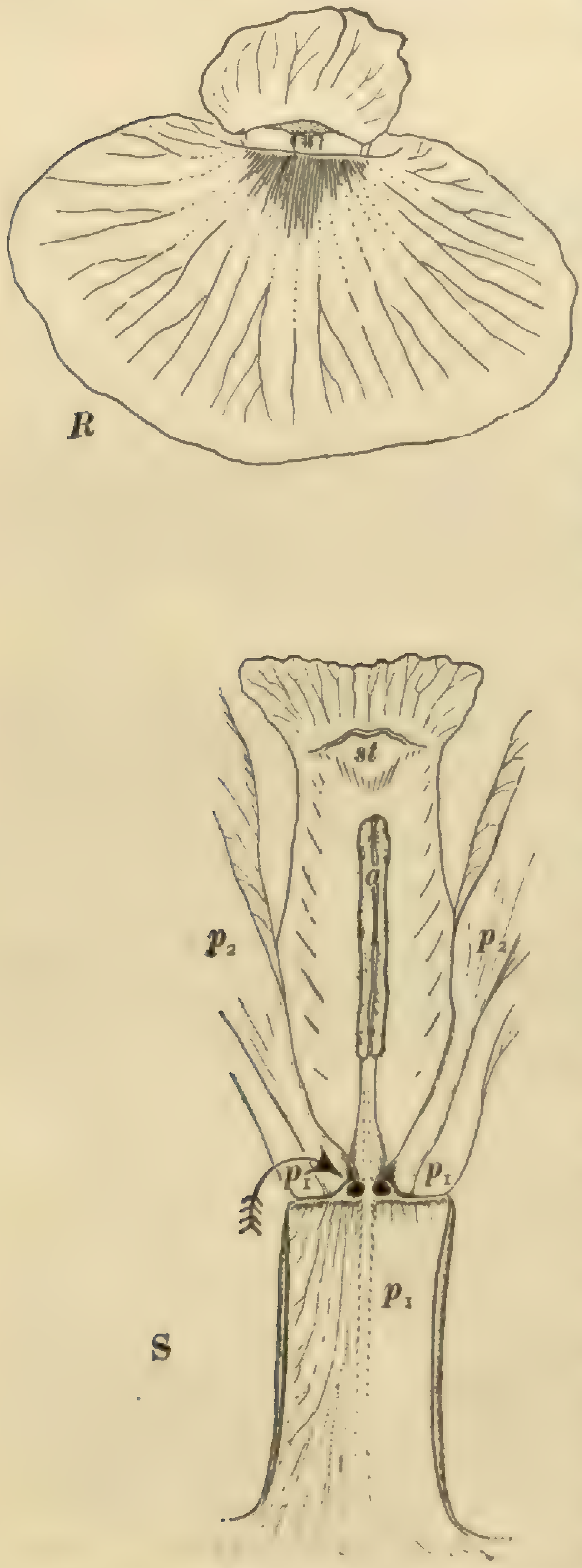

Fig. 1. — The entrance to the Iris flower, *R*, as seen from the front; parts undisturbed; *S*, as seen from the side with the sepal pulled directly downward; p_1, sepals; p_2, petals; *a*., anther; *st*., stigma. The arrow indicates the position of the proboscis of a pamphila when stealing the nectar.

elastically, and the rubbing of an emerging insect only closes it the more tightly.

Although the flowers are slightly protandrous, ripe pollen and fresh stigmatic surface may be found in the same flower at some period of æstivation. In case insects fail there is no provision for self-pollination by withering, as is the case in some members of the Iris family; the stigma, lifted away from the anther before maturing, remains so permanently.

I shall now discuss briefly the insects which I have seen to enter these flowers, taking them up in the order of their importance as agents of pollen distribution. I therefore begin with two small bees of closely similar size and habits: *Clisodon terminalis* Cr., *Osmia distincta* Cr.

These bees exhibit such perfection of adaptation as was the delight of the naturalists of Sprengel's day, and as will ever be delightful to observe. They were seen only in warm sunshine, during the season of abundant flowers; late and straggling flowers seemed to be neglected by them altogether. They were not the most numerous nor the most conspicuous visitors; but they visited very many flowers in rapid succession, securing the transference of the pollen with superior precision.

Each bee alights squarely at the entrance and without the slightest pause speeds down the arched passageway, and does not stop until its head is wedged in the bottom, with the proboscis extended through one of the two holes (see Fig. 1, *S*) leading to the nectary. A step backward and another momentary thrust of the proboscis, and away to another flower. That it rubs the stigma on entering may be seen by the tilting of the style tip; this is readily seen at a distance of several meters. *Osmia distincta* was perhaps a little less swift in its passage than the other, and this species alone was seen occasionally stopping on the way out from the nectary to scrape up some of the pollen fallen beneath its feet.

Next in order should be mentioned a group of syrphus flies: *Helophilus lætus* Loew.; *Syrphus torvus* O. S.; *Eristalis dimidiatus* Wied. Of these the first-named was a very common visitor. Of the other two I saw but a single specimen of each on Iris flowers, although the last-named was abundant on flowers

of the spreading dogbane. These are a little larger than *H. lætus*, and probably found the entrance way to the flower too close quarters. *H. lætus* visits the flowers for pollen only. Its proboscis is too short to reach the nectar. It wanders in at the entrance, rubbing first the stigma and then the anther with its back, swinging its proboscis from side to side, the terminal flaps sweeping the fallen pollen from the floor of the passageway. The down of its back was generally found well dusted with Iris pollen, and as an agent in pollination it was certainly second only to the bees above mentioned.

In the method of their operations these bees and syrphus flies stand in striking contrast. The bees enter and leave the flowers on the run, visiting very many in a remarkably short time; the syrphids loiter about the entrance, turning this way and that and, although entering cautiously, remain inside some time; but between visits they spend much time disporting themselves with their fellows in the sunshine. While a syrphus fly is visiting one flower a bee will visit a score.

Bombus separatus Cr. — The Iris and the bumblebee were the subjects of one of Sprengel's early studies on the relation between flowers and insects. Sprengel thought the bumblebee the only insect concerned with the fertilization of the European species (*Iris germanica*) which he studied. Müller attributed rather more importance to a very long-tongued, nectar-eating syrphid, *Rhyngia rostrata.* American writers on *Iris versicolor* have treated the bumblebee as the visitor of first importance. My observations do not corroborate this opinion. I saw but three bumblebees on Iris flowers during the entire season, and each of these was seen but a few seconds, entering from one to three flowers at one side only, and then departing. The visits were not such as bumblebees make to flowers which they habitually seek. They showed evident dissatisfaction. Indeed, they seemed to me ill-adapted. They are too large; they enter with difficulty and some delay, and crowd the stigma too roughly in passing. In the single visit which I was able to observe in detail the stigmatic flap was torn from the style for half its width; the bumblebee descended the passage with its proboscis retracted, made no

attempt at sucking, but scraped the trough of the sepal with its legs, gathering pollen.

Halictus disparilis Cr. — This minute bee is a common, though not a conspicuous nor an important visitor. It enters the flower by crawling beneath the tip of the style back downward, traverses the stigma, and walks back and forth, the length of the anther clinging to its underside, dislodging with its claws large quantities of pollen (Fig. 2). A strikingly large load of pollen is thus collected upon the hairs of its ventral surface. So it spends a long time under a single anther and visits but few in gathering its load. While it is highly probable that the bee everts and pollinates the stigma on

FIG. 2. — A minute bee (*Halictus disparilis* Cr;) collecting pollen from the Iris anther; *a.*, anther. *f.*, filament; *st.*, style. The arrow indicates the course of an insect entering the flower.

entering, it is certainly very wasteful of pollen. A more equitable arrangement is seen in its relations with *Ludwigia polycarpa*, which it visits in pools near by, and whose small flowers will furnish a load of pollen only for the traversing of a multitude of stigmas.

Trichius piger Fabr. — This ubiquitous flower beetle, observed by Robertson at Carlinville in the flowers of *I. versicolor*, was rather common here. The channeled sepal seemed a favorite place for an afternoon nap. I found several there undoubtedly asleep — one so soundly that, after carrying it about in the flower in my hand for half an hour, I still had a chance to wake it. After repeatedly tickling two of its feet that were hanging over the edge of the sepal it at length stirred, then stretched itself like a lazy boy awaking; in a little while it was lively enough.

I saw one beetle in the passageway eating fallen pollen. The species is not ill-adapted by its size for visiting these flowers, and should it pass directly from flower to flower, it

might be an important agent in pollen distribution; but I have not seen one pass from flower to flower directly and am inclined to think it rarely does so. It is little disposed to flight and is much more at home clambering among the thyrsoid clusters of Rhus and Ceanothus. Furthermore, on reaching an Iris flower it is habitually deceived as to the point of entrance and tries for some time to get in at its center, between the branches of the cleft style. After clambering in and out of the central cleft repeatedly the proper entrance is at length stumbled upon. It cannot, of course, reach the nectar, and the supply of pollen on the floor of the passageway is very meager. If seeking pollen it might, if it had wit enough, get plenty of it by entering the other side up.

Mononychus vulpeculus Fabr. (*the Flag Weevil*). — This beetle is one of the most characteristic insects affecting the blue flag, and one of the commonest. It is often found in the passageway to the nectary, picking up stray pollen grains, other grains sticking to its rostrum and feet and to the scaly ventral surface of its body, but not to its smooth back. What has been said of the preceding species, as to its part in pollen transference, and as to its activities in and about the flower, will apply almost literally to this species.

Desiring to learn whether they would transfer pollen properly, and finding too few entering the flowers of their own accord, I picked up a number of them with forceps and placed them in various positions on the flowers. They all, wherever placed, ran rapidly into the central cleft of the style, seeking to enter there, climbed out, and returned to try it again repeatedly. A few then climbed out at the sides between two sepals and crawled through the space between sepal and style into the entrance way, without touching either stigma or anther. A far larger number came upon the proper entrance. Most of these latter climbed over the tip of the style and down its outer face, entering back downward, traversing both stigma and anther. A lesser number wandered out upon the tip of the sepal and returned to enter right side up; owing to the lack of pollen on their smooth backs, these would effect nothing, though they touched the stigma.

Single individuals taken from the flower again and again and replaced on top, though they sought to enter speedily, went about it in the same bungling way as before. They did not readily learn by experience.

Xylota fraudulosa Loew.; Sepsis violacea Meig; Chlorops proxima Say; C. assimilis Macq.; Chrysogaster nitida Wied. — These active little flies are minor pollen thieves, all small enough to run into the open passageway, gather a few pollen grains, and run out with them. The first is large enough to brush a low stigma in passing, and the second, a strutting, micro-hymenopter mimicker, might strike a stigma with its tilting wings; but all are very unimportant, both in pollination and in their petty thievery.

Lastly, I should not omit to mention thrips, a few of which are to be found in almost every flower, and, antithetically, a humming bird (*Trochilis colubris* Linn.) which I saw make several thrusts, in succession, with its beak into the proper entrance of these flowers.

II. The Waste of the Nectar.

Two important sources of waste of nectar were much in evidence throughout the season — lepidopters and weevils.

A. Lepidoptera. — These were, by day, skipper butterflies (Hesperidæ), and at dusk, two species of moths[1]:

Eudamus tityrus Fabr., seen at flowers several times.
Eudamus pylades Scudd., seen at flowers but once.
Pamphila hobomok Harr., seen at flowers continuously.
Pamphila peckius Kirb., seen at flowers continuously.
Pamphila cernes Bd.-Lec., seen at flowers continuously.
Pamphila mystic Scudd., seen at flowers not uncommonly.
Leucania pallens (?), seen at flowers several times.
Evergestis stramentalis, seen at flowers several times.

The pamphilas were the most conspicuous and persistent of all visitors. Throughout the season one could find at even the

[1] Another moth, *Crambus laqueatellus* Clem., was seen twice, vainly plying its proboscis at the proper entrance.

smallest clump of flowers one or more of these skippers sitting in the position shown in Pl. I, Fig. *b*, far from anther and stigma, stealing the nectar. They get it with some difficulty, to be sure, the holes opening into the nectary not being visible from the outside. They must stand outside and insert the proboscis obliquely between the sepal and the base of the style, plying and thrusting with it until a hole is found. Repeated trials occasion loss of time, and when the hole is found not all the nectar adjacent to it can be reached from one position. Nevertheless, one cannot witness the persistences of the skippers, and their abundance throughout the season, without being convinced that they get a large share of the nectar.

Very interesting as bearing on the validity of long-accepted theories of floral coloration (which some are nowadays saying were accepted without sufficient experimental proof) are the habits of the pamphilas in visiting the flowers. When the question is raised, Do the guide streaks really guide? the pamphilas on the blue flags will furnish affirmative evidence. Fig. 3 shows a flower as seen from above. The center of the flower is at the deepest point between the divisions of the style, and the lines of these divisions all point toward the center, analogously to the guide streaks on the corolla of Convolvulus. There are special guide streaks, to be sure, at the proper points of entrance; but these are in unusual places and are also arranged radiately about the center of the flower. Pamphilas visiting the flowers *habitually try to enter at the center.* One will roam over the summit of the flower, returning to try for entrance at the central cleft, again and again. When one has strayed to the end of the style branch and stumbled upon the right entrance, it will generally be seen to try for a moment to enter there. After several ineffectual attempts at the center, it will pass over the edge of the sepal and descend backward or sidewise to the position shown in the plate (Fig. *b*). That something similar was observed by Professor Charles Robertson is indicated by the two words which I have underscored in the following quotation: "Sometimes butterflies obtain nectar in an illegitimate way, by *backing down* to the base of the flower and inserting their proboscides between the bases of the

'falls' [sepals] and the style divisions."[1] He mentions *Chrysophanes thoe* Boisd. and Lec. and *Pamphila peckius* Kirb.

I have mentioned above that the flower beetle, *Trichius piger*, and the flag weevil, *Mononychus vulpeculus*, are deceived as to the proper entrance in a quite similar manner, with the difference that when these stumble upon the true entrance they can enter there. I have never seen any one of these ill-adapted visitors alight directly at the proper entrance; all fol-

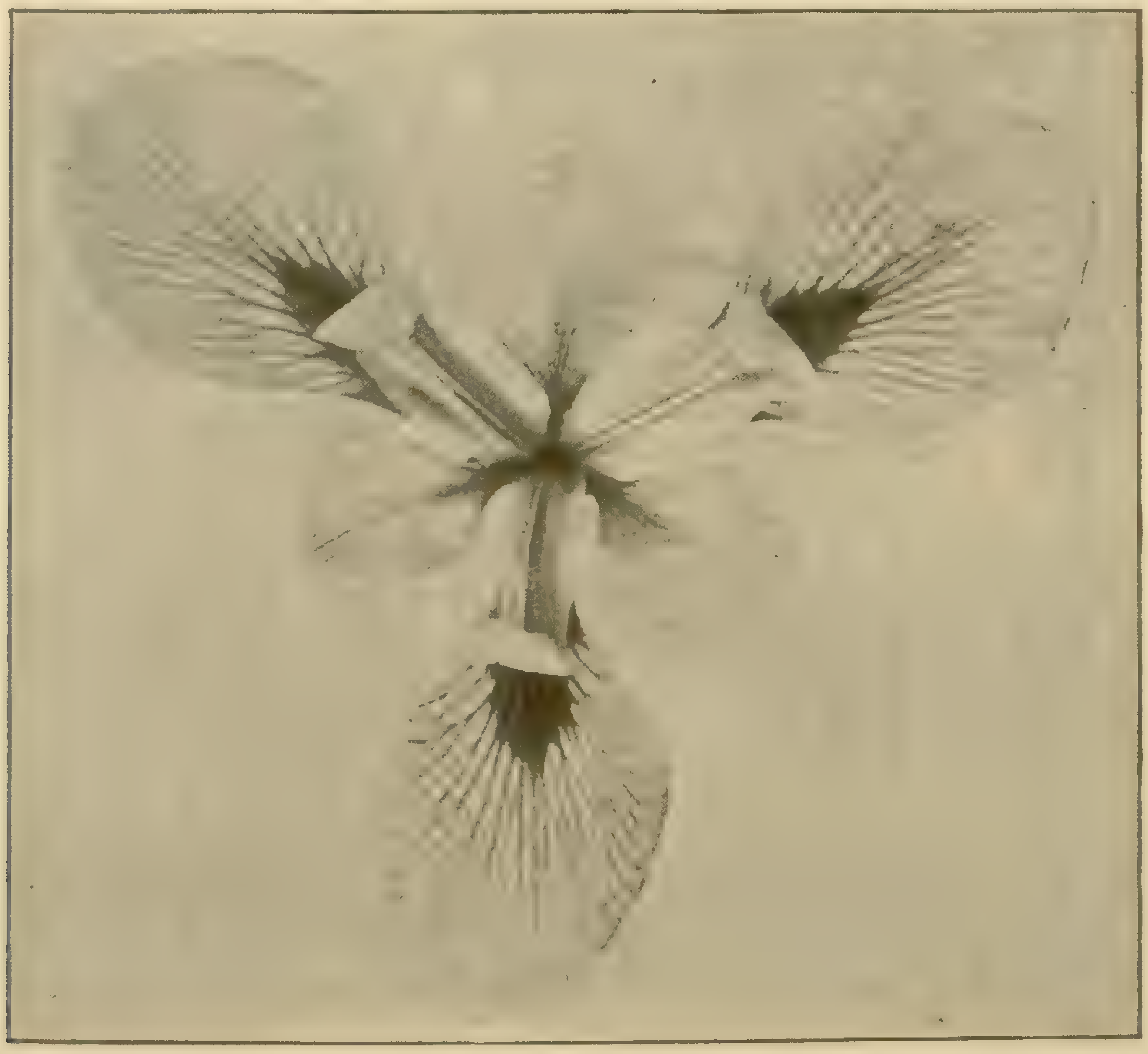

FIG. 3. — Top view of the flower; false guide streaks.

low to the center the lines simulating the guide streaks of an ordinary open flower. But the Iris flower was not evolved by these insects, nor with them. Proper visitors know where the entrance is and make no mistakes. And if the bees aforenamed pass from nectary to nectary with a speed that the eye can hardly follow, must we conclude that they are not guided by the coloration of the flowers? Must we say the striking lines of violet and yellow at the entrance aid them not, because they give no sign? I think not. I may enter a barber shop guided entirely by a striped pole and yet give no sign. I

[1] Robertson, Charles. *Botanical Gazette*, vol. xxi, p. 80, 1896.

believe it an analogy which does no violence to the truth if we compare a clump of the flowers to a business block in a city. Those whose business is there go about so automatically one might think they see nothing, while strangers have to stop and read the signs; and the rapidity with which the stranger will learn to feel at home will depend, not alone upon the persistency of his presence there, but also upon his mental adaptability to such knowledge.

B. MONONYCHUS (*the Flag Weevil and its Train*). — This weevil wastes the nectar inordinately. It stands on the outside of the nectary and, with its beak, sinks a shaft into the nectariferous tissue, nibbles a little, makes another hole, and another and another, until the nectar is left flowing from many punctures, attracting swarms of insects of all sorts. One is shown in Fig. *A* of the plate, together with a number of its attendants. It is no uncommon thing to find the ovary almost covered with insects following in the wake of the weevil, collecting the sap it has set flowing. The muscids are most numerous; I have seen a weevil making a puncture with three flies facing him and one on his back, all trying to get their proboscides to the puncture, crowding one another like pigs around a trough. During hours of sunshine, competition is so keen that insects with proboscides to insert into the beetle punctures (Muscidæ, Capsidæ, Pentatomidæ, etc.) seem to have a decided advantage. I have seen the following feeding at the weevil punctures:

Muscidæ, abundant, of a number of common species.

Capsidæ, abundant, especially the first named:

- *Pœcilocapsus goniophorus* Say, in four varieties.
- *Pœcilocapsus affinis* Reut.
- *Calcoris rapidus* Say.
- *Lygus pratensis* Linn.

Pentatomidæ, very common.

- *Euchistus ictericus* Linn.
- *Euchistus tristigmus* Say.
- *Podisus spinosus* Dall.

Coccinellidæ, common.

- *Megilla maculata* DeG.
- *Hippodamia 13-punctata* Linn.

Lampyridæ, common at dusk and on dark days, especially the first-named:

Telephorus carolinus Fabr.
Podabrus basilaris Say.
Podabrus rugulosus Lec.
Lucidota atra Fabr.

The following insects, seen more rarely :

Mordella marginata Melsh.
Prosopis affinis Smith.
Prosopis nelumbonis Robt.
Worker ant (undetermined).
Male mosquito (undetermined).

III. The Destruction of the Flowers.

The flowers of the blue flag when bitten have a sweetish taste, which seems to invite their destruction at the jaws of a number of insects that are ever near at hand. I observed adult flag weevils, noctuid moth larvæ, and grasshoppers to be especially destructive while the flowers were in full bloom.[1] Any service the weevils may render as pollinators is greatly overbalanced by the destructiveness of their feeding habits. Not content with puncturing the walls of the nectary, they sometimes riddle the perianth leaves and the style divisions, destroying or (what is equally fatal) displacing the parts concerned in fertilization.[2]

All the grasshoppers (Acrididæ and Locustidæ) about the flag beds and in the neighboring sedges eat the freshly opened flowers, mainly nibbling a little at the margins of the petals or sepals and doing little real harm, but sometimes destroying the flowers completely.

The destructive moth larvæ were of three species : *Arsilonche albovenosa* Goeze, Mamestra *sp.* ?[3] and *Spilosoma con-*

[1] Feeding upon the wilted flowers a day after they had closed and when their sap was souring were frequently observed the three following beetles : *Trichodes nuttalli* Kirb. ; *Megilla maculata* DeG. ; and *Telephorus carolinus* Fabr.

[2] This weevil has been reported by Mr. G. C. Davis as very destructive to imported garden Irides, at Flint, Mich. *Insect Life*, vol. vii, p. 201, 1894.

[3] I did not rear this species; two of my larvæ taken for rearing were parasitized with a species of Apanteles ; the remainder (as well as many in the field) died of some bacterial disease. *Arsilonche albovenosa* was abundantly parasitized with *Rhogas intermedius* Cr.

grua Walk. At the time the Iris flowers opened, these larvæ were well grown. They then forsook the leaves, on which they had been feeding hitherto, for the daintier floral diet.

Chætopsis ænea Wied. and its Train. — This little bud-destroying ortalid fly deserves special mention, because in certain situations it does more to prevent fruiting than all other insect enemies combined. Furthermore, its attack comes earliest; its larva enters the pedicel at the base of the flower bud and bores downward into the common flowering stem (peduncle), killing not one bud, but the cluster of two or three arising at that point. Thus the flowers are killed before they open and are left to decay.

Walking through a pasture near Lake Bluff, Ill., one day, I was led to examine some large clumps of flags by the very bad odor of their Chætopsis-killed flowers. In clumps of several hundred plants each, not a single flower had been permitted to open. Finding Chætopsis larvæ still present in some of the pedicels, I collected a hundred or more terminal branches of the flower clusters and placed them on end in a jar, with a little water, some gravel, earth, etc., in the bottom, covered the jar with fine netting, and set it aside to await developments.

My little jar yielded, not a single species, but a little community — a succession of interdependent forms, such as one often finds among insects with a brief life history, able to take advantage of a transient food supply. First there appeared a number of pomace flies (*Drosophila phalerata* Meig), which had probably been attracted to the buds by the souring of their saccharine juices. Next appeared the ortalids (*Chætopsis ænea* Wied.), the cause of all the trouble. These I found left the stems when full-grown larvæ and pupated on the wet soil in the bottom of the jar. By this time the rotting buds were teeming with oscinid larvæ and studded all over the outside with pupæ, from which soon issued swarms of the minute fly, *Oscinis soror* Macq. With these also appeared a small number of beetles (undetermined) and a few parasitic Hymenoptera (*Spalangia drosophilæ* Ashm. and Heptamerocera *sp.*?). Finally, after the decaying buds had been completely overrun with mycelial

threads of fungus, there appeared fungus gnats (*Scatopse pulicaria* Loew.) in great numbers. It is quite probable that the ortalids attacking the fresh buds, the pomace flies coming when the saccharine juices of the flower first begin to ferment, the other flies and beetles clearing up the rotting débris, with a few parasites to hold the commonest in check, form an entirely natural succession of forms belonging with such conditions.

IV. Fertilization.

Not wishing to leave actual fertilization out of account, I (1) pollinated by hand a large number of flowers and marked them for examination later, and (2) counted the fertile and abortive ovules in a large number of capsules developing from flowers fertilized by insects. In my hand-pollination experiment half the flowers were treated with their own pollen, half with pollen from other plants. Before the seeds had grown sufficiently to be distinguished with certainty from the abortive ovules, grasshoppers and Mamestra larvæ had eaten all but a few. Those that remained happened to be half self-pollinated, half cross-pollinated, and the result may be worth mentioning, even though they were but few. The average by capsules was as follows:

Cross-pollinated,	ovules,	79;	fertilized,	74,	unfertilized,	5 (for 2 capsules).
Self	"	" 82;	"	16,	"	66 (" 2 ").

These were small capsules, from flags growing among thick sedges.

In a flourishing flag clump growing in the edge of a woodland pool I selected thirty well-developed capsules from flowers fertilized by insects, for the following tabulation. The position of the several capsules in the cluster is indicated by the lettering in the first column, which is the same as that of Fig. 4.

Table I. — Averages of Fertilization by Insects for 30 Capsules.

Capsules.	Average Number of Ovules.	Fertilized.	Unfertilized.	Per Cent Fertilized.	Number of Capsules Counted.
I *a*	126	74	52	58.73	10
I *b*	129	57	72	44.96	5
I *c*	114	32	82	28.07	5
II *a*	123	44	79	35.77	5
II *b*	113	40	73	35.39	5
Totals	122	43	68	43	30

V. The Destruction of the Seeds.

I observed two types of seed destroyers, ecologically speaking: (1) those which are locally destructive, and (2) those which are with the flag in all the situations in which it grows. The influence of situation will be discussed under a subsequent heading, but here may be mentioned the insects locally destructive to the developing seeds. These are grasshoppers, Mamestra larvæ, and ovipositing damsel flies of the genus Lestes.

The grasshoppers are very destructive in meadow clumps and in the drier, more grassy situations, sometimes eating all the capsules over considerable areas, while generally disdaining to eat the leaves at all.

Of the three moth larvæ already mentioned as feeding on the flowers, only Mamestra remains to attack the developing ovary; the others return to their aforetime diet of leaves. But Mamestra, having once bitten into a juicy capsule, will eat nothing else thereafter, so long as capsules are obtainable. In my rearing cages a single larva would eat out all the seeds from a well-grown capsule in two days. Mamestra hardly comes into competition with the grasshoppers, since it avoids the drier situations where these are numerous enough to be destructive.

The injury from Lestes was still more local and was of a sort apparently not hitherto recorded. It was confined to flags

growing in standing water. The sheltered pools in which the Iris thrives best are the special haunts of these insects. *Lestes uncata* Kirby and *L. unguiculata* Hag. were abundant, and the females of these species punctured the fruiting stems so thickly in ovipositing as to kill perhaps a fourth of them. These egg punctures sometimes completely encircled the stem, but were more often confined to the more exposed side, overhanging the water. I observed as many as 250 punctures to the inch in length of stem in several cases. All were above water, some extending nearly to the top of the stems.[1] Nearly every well-exposed stem was thus killed outright or so injured as to prevent the maturing of its seeds.

Many other Odonata are seen constantly about the flag clumps. Longfellow singled out a natural associate when he wrote of the Fleur-de-lis:

> The burnished dragonfly is thine attendant;

but the showier dragonflies which habitually poise on the summits of the sword-shaped leaves have no ecologic relation to the Iris, save indirectly through their relations with other insects.

Of ubiquitous flag-seed destroyers I have found but two; the larvæ of a very pretty little tortricid moth, *Penthina hebesana* Walk., and the larvæ of the flag weevil (*Mononychus vulpeculus* Fabr.). The moth larvæ were common, the weevil larvæ, abundant; both were often found attacking the same capsule.

The larva of Penthina bores a hole into the seed capsule at its base, generally under the protecting tip of a bract, and eats its way upward through the seeds, usually consuming in its lifetime about half the contents of a single cell. Then it undergoes its transformations under the bract, or withered perianth, or in its burrow.[2]

[1] Egg parasites of Odonata have not in this country been hitherto reported; I bred from these Lestes eggs in flag stems five species of egg parasites and one hyperparasite, all of which proved to be species new to science. These are now in Mr. Ashmead's hands for description. These species of Lestes oviposit even more abundantly in Spharganium leaves.

[2] With this species there was occasionally found another tortricid (*Cacœcia rosaceana* Harris) of almost identical habits.

The flag weevil (*Mononychus vulpeculus* Fabr.) has already been mentioned as a denizen and, to some extent, a destroyer of Iris flowers. The height of the season for the adult weevils is the blossoming time of the flowers. Even then they are not very active; I have found them flying freely from clump to clump only in the hot sunshine of early afternoon. They will dodge around the base of the flower like a squirrel around a branch when a hand approaches, but they will rarely fly; they will oftener fall to the earth or into the water. The females when ovipositing are still more shy and difficult to observe. I was able to see the details of the process of egg laying on only one day — a very windy day, when everything about the weevil was in motion, and my own movements were, therefore, less noticed. The mother beetle rapidly gnaws a little hole through the wall of the ovary and, taking a few steps forward, inserts an egg into it. She then walks a little way and repeats the process or gnaws aimless little pits over the surface of the ovary.[1] The wounds thus made are quickly stopped by the discharge from mucilage cells, which are abundant in the walls of the ovary. The egg is often inserted into the external face of an ovule.

When the egg hatches, the larva at once begins a shallow furrow across the outer ends of the developing seeds, traversing from two to ten of them. Thus it spends the larger part of its larval life, doing no damage whatever. In fact, during this stage it is in considerable danger of being eaten, along with the seeds, by grasshoppers or Mamestra larvæ. Entering upon its last larval stage, the larva burrows downward and begins feeding on the softer tissues of the center of the seeds. It eats voraciously and grows with marked rapidity. It burrows parallel with the axis of the capsule through the center of from three to five seeds, leaving of them only empty rings. Its growth is completed and all its damage is done during this stage, which lasts only about a week. Then it transforms

[1] Possibly these blind pits may serve for the confusion of the weevil's parasites. I found a little egg, presumably that of a parasite, just within the entrance to a hole, at the bottom of which a weevil egg was lying. Mr. J. Hamilton found the parasites (*Ent. News*, vol. v, pp. 287, 288, 1894).

within its burrow and remains there as an imago, until the bursting of the capsules in autumn causes the seeds and the weevils to be shed together.

To determine the extent of the damage done by the weevil to the flag seeds, I picked at random, in several situations, fifty well-developed capsules and counted the weevils in them. The result by capsules was as follows:

Number of larvæ per capsule,	0,	1,	2,	3,	4,	5,	6,	7,	8,	9,	10,	12,	15,	16.
Number of times occurring,	3,	2,	4,	8,	4,	11,	3,	6,	1,	1,	2,	1,	1,	1.

Thus, but three were found without larvæ in them; two contained such numbers (fifteen and sixteen, respectively) that there were hardly enough seeds to insure their development; the total number of larvæ was 269, the average number per capsule, five. Each larva destroys on an average about four seeds; a preceding table has shown that the average number of seeds developing per capsule (among thirty counted) was forty-three. So it appeared that the weevils destroyed nearly half the seeds in capsules which had escaped other destroyers, all of which had had their turn first.

While this weevil is the most constant enemy of the blue flag, it is at the same time the one best regulated. Unlike other enemies, it is present on or in the plant throughout the season, and, though occurring everywhere, it is never wholly destructive anywhere. Its own habits furnish checks to too great multiplication. This is but saying that the weevil represents a higher type of ecologic specialization. It has become adapted for living on the blue flag exclusively. Other enemies might totally devastate the flag clumps and, in the next generation, turn to some other food plant; but excessive injury by the weevil means future starvation for its kind. The grasshoppers, Mamestra and Chætopsis, work a havoc that strikingly suggests a disturbance of the balance of nature. But the weevil goes its accustomed way — the way into which it has been led by natural selection — and gets its living unobtrusively; and save for the rather rare damage to flowers, which may as often be done after fertilization as before, the flags show no visible sign of the burden which, under natural conditions, they are doubtless able to carry.

VI. Inflorescence, and Chances of Maturing Fruit.

The flowering stem of *I. versicolor* bears a terminal cluster of three flowers and generally one or more lateral clusters of two flowers [1] each, the latter springing from the axils of alternating bracts. Fig. 4 represents a stem which bore the typical complement of flowers. For convenience of reference I designate these clusters by the Roman numerals applied to them in the figure. Cluster *I* is developed in all (100 per cent); cluster *II*, in about 60 per cent of the stems; cluster *III*, in about 10 per cent of them; and cluster *IV* is rarely developed; I found it but once during the season.[2] The small letters indicate the several flowers in the clusters and also the order of their opening. The clusters are nearly isochronous, but there is some irregularity. Flower *I a* is generally the first to open. The few flowers which I marked for observation opened in the morning before nine o'clock, and closed by withering during the afternoon of the day following. Flowers *a*, *b*, and *c* follow each other in regular succession, each being

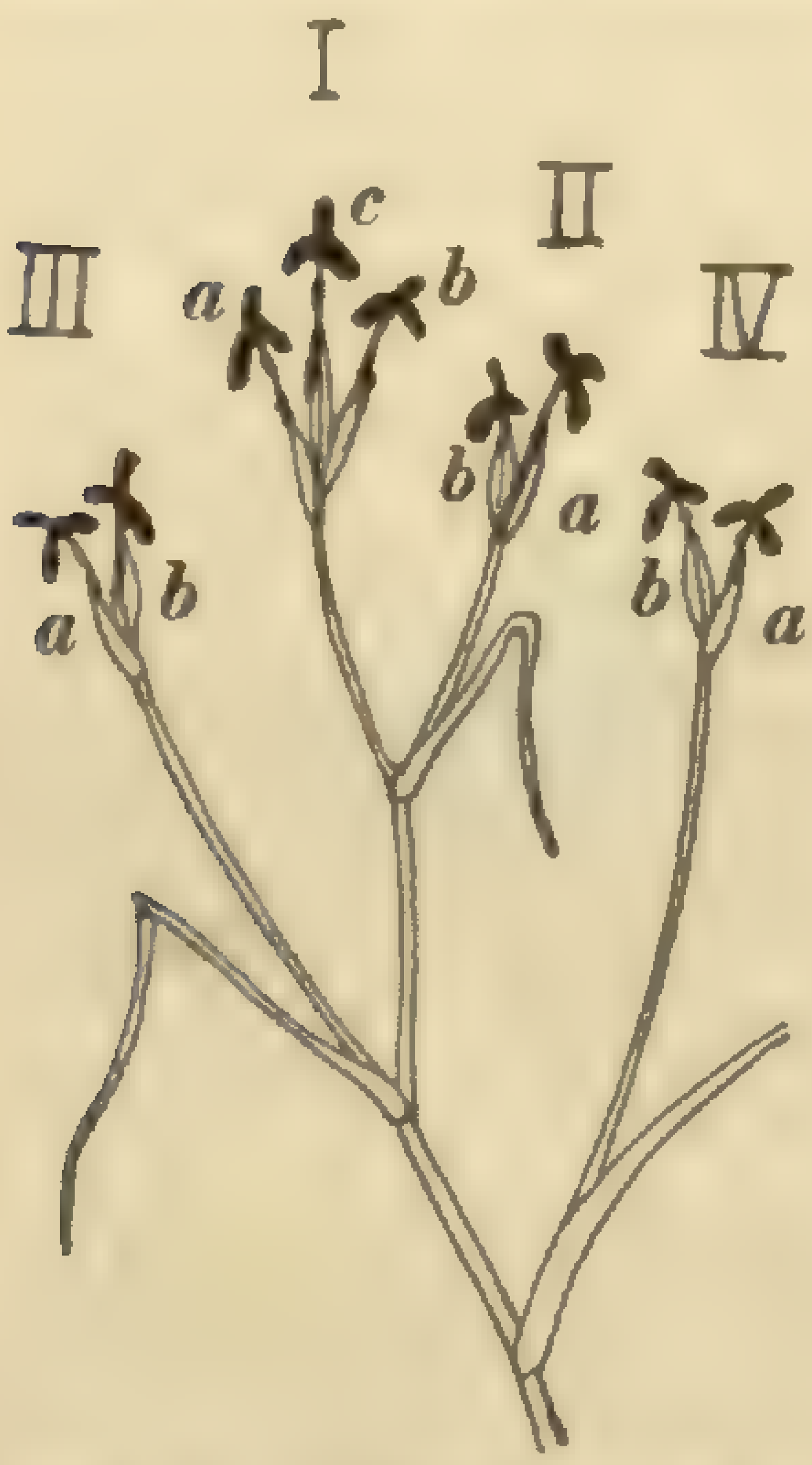

Fig. 4. — Diagram of the flower cluster.

[1] The statement of Goodale (*Wild Flowers of North America*, p. 32, 1882) that "the flowers may be single or in clusters of two, rarely more" is certainly not true for the vicinity of Lake Forest; I found but a single clump to which it would at all apply — a clump of much-dwarfed plants growing on a very dry hillock in a pasture near Fort Sheridan. This singular clump bore twenty flowering stems, of which five had cluster *I* only, with but two flowers (*a* and *b*) in that cluster; twelve had clusters *I* and *II* developed, with the second flower (*b*) developed in *II* but twice; and three with clusters *I*, *II*, and *III* developed, and only one flower (*a*) present in cluster *III*. Elsewhere I found three examples of cluster *I* in which a fourth flower (*d*) was developed, and two in which the third flower (*c*) was not developed. The usual four bracts were developed in all; but the terminal bract, usually sterile, was fertile in three, and the third bract, usually fertile, was sterile in the other two. I also found a single cluster *II* containing three flowers.

[2] These percentages were derived from a count of 214 stems — the same ones which were used in drawing up Table II. A subsequent count of 129 stems from other localities near Lake Forest yielded slightly different results, as follows: cluster *I* developed in all (100 per cent); cluster *II* developed in 87 (67.5 per cent); cluster *III* developed in 21 (16.3 per cent).

open for two days. Sometimes there is an interval of a day or two with no flower open. Some striking differences in time of flowering, due to situation, will be noticed under the next heading.

I collected 214 stems from five different localities and studied them to determine the proportionate fertility of the several capsules. Wholly infertile stems I disregarded altogether, and capsules developing any seed at all I counted fertile; Table II summarizes the results of the count. Disregarding localities for the present, the total percentages of fertility are as follows:

Flower	*I a*, 75 per cent;	*I b*, 63 per cent;	I *c*, 28 per cent.
"	*II a*, 66 per cent;	*II b*, 43 per cent.	
"	*III a*, 68 per cent;	*III b*, 54 per cent.[1]	

Clearly, the advantage is with the earlier flowers.

But is there not further significance in these facts? In connection with the occasional occurrence of an extra flower in clusters *I* and *II* they seem to me to suggest that the flower cluster is in process of reduction by elimination of the later flowers. The observations of one season will not determine such a matter. It is sufficient to record the conditions of the present, that the future student may have the criteria necessary for determining it.

VII. The Relation of Habitat to Fertility.

My observations were all made on the eastern slope of the narrow Lake Forest moraine, which forms a part of the west shore of Lake Michigan, its wave-worn eastern edge rising abruptly some seventy feet from the water. Numerous sharp, post-glacial ravines, whose puny streams take their origin among the pools, marshes, and "potholes" of the crest of the moraine and reach the lake level only at their mouths, give considerable variety to the otherwise uniform and scarcely perceptible eastward slope. I found and studied the blue flag growing in eight different sorts of situations. These will be referred to by numbers in the succeeding tables, as follows:

[1] The higher percentages for cluster *III* are somewhat misleading, because this cluster is developed only under the most favorable conditions.

Locality 1. — A small clump of perhaps fifteen plants, growing in the edge of a little creek that was formed by the confluence of a number of ravines, near the lake and almost at the lake level. But one clump was found in this situation, and it bore but fourteen flowering stems; but, because of its striking vigor, fertility, and comparative exemption from insect enemies, it is included in the table.

Locality 2. — A large area of flags, growing in an upland meadow pool that was the head water of one branch of the forementioned creek. This was the most extensive and the most typical of the clumps studied.

Locality 3. — A large and compact clump, growing in the edge of a woodland pool.

Locality 4. — Isolated single plants, growing between the sedges and the open water in a woodland pool.

Locality 5. — A large number of scattered plants, growing among the sedges of a "filled-in" pool.

Locality 6. — A typical glacial "pothole" in deep woods on the summit of the moraine, with abrupt banks, some depth of water in the middle, closely bordered with great oaks, and almost filled with a dense growth of buttonbush (Cephalanthus). The flags grew between the buttonbush hummocks and the shore, tall and spindling, with remarkably pale flowers. They bloomed late, the water of the pothole being rather cold, and, with the exception of two flowering stems which grew upon an unoccupied hummock, set no seed at all; hence this locality is omitted from Table II.

Locality 7. — At the foot of a hill bordering the creek mentioned above (locality 1), in a pool of cold water, the outflow from a spring, grew perhaps fifty plants, intermixed with cattails and sedges. These made a very promising appearance, but they bloomed late; the flowers were considerably damaged by weevils and set little seed, and that little was early destroyed and none left for tabulation.

Locality 8. — In a bottom-land pasture bordering the creek numerous large, apparently healthy, clumps on dry ground. This ground had once been marshy bottom land; but as a result of pasturage, tillage, and deforestation of the hills above floods

Pl. I.—Two Iris flowers, with some illicit visitors. Entering the cleft in the style of flower *a*, *Pamphila peckius* Kirb.; on the left side of the nectary, a flag weevil (*Mononychus vulpeculus* Fabr.) surrounded by a group of Muscidæ; below, a lampyrid (*Telephorus carolinus* Fabr.), also seeking nectar. On flower *b*, *Pamphila cernes* Bd.-Lec. stealing the nectar; *n.*, nectary; *o.*, ovary. This, and Fig. 3, photographed from life by the author.

had increased, and the creek had deepened its channel, leaving the flag clumps high and dry. The flowers were destroyed by Chætopsis, setting no seed at all.

Thus, only the five first-named localities were available for the following tabulation.

TABLE II. — COMPILATION OF DATA ON IRIS FRUITING.

Clusters.	From	No.	Capsules Fertile.								By Clusters.				
			a.	*Percentage.*	*b.*	*Percentage.*	*c.*	*Percentage.*	*Total.*	*Percentage.*	*All Abortive.*	*Both a and b Fertile.*	*Percentage.*	*a, b, and c Fertile.*	*Percentage.*
I	loc. 1	14	10		9		9		28	66%	0	8	57%	7	50%
	" 2	125	95		81		36		212	57%	0	74	59%	34	27%
	" 3	25	18		20		8		46	63%	0	13	52%	3	16%
	" 4	25	21		18		6		45	63%	1	16	64%	6	25%
	" 5	25	17		7		2		26	35%	0	7	28%	1	4%
	Total	214	161	75%	135	63%	61	28%	357	56%	1	118	55%	51	24%
II	loc. 1	10	7		4				11	55%	0	4	40%		
	" 2	75	56		39				95	63%	2	38	50%		
	" 3	15	10		7				17	57%	4	6	40%		
	" 4	13	8		5				13	50%	3	4	34%		
	" 5	15	3		0				3	10%	12	0			
	Total	128	84	66%	55	43%			139	54%	21	52	41%		
III	loc. 1	7	5		6				11	79%	0	5	71%		
	" 2	12	8		4				12	50%	0	3	25%		
	" 3	1	1		1				2	100%	0	1	100%		
	" 4	1	1		1				2	100%	0	1	100%		
	" 5	1	0		0				0		1	0			
	Total	22	15	68%	12	54%			27	61%	1	10	45%		
IV	A single example from loc. 1, both capsules fertile.														

This study by localities shows that the flags which grow in shallow water with open exposure to the sun have the better of it. Doubtless this but indicates their natural habitat.

The inference previously drawn from this table, that the earlier flowers have the advantage, is strikingly corroborated

by the study of localities 6 and 7, in which cold water and consequent late flowering are accompanied by nearly total infertility. While various reasons might be assigned for this advantage, I am inclined to believe that the principal reason is the coincidence of the visits of the bees, pollen distributers *par excellence*, with the time of blossoming of the early flowers.

The following table expresses in general terms the relation which ravage by insect enemies was seen to bear to situation. The first three columns express broadly the more potent features of the several situations. In six columns are indicated, by abbreviations of their respective scientific names, the six chief insect enemies: Mononychus, Penthina, Mamestra, Arsilonche, Orthoptera (grasshoppers), and Chætopsis; the numbers in these columns merely indicate the relative destructiveness of the insects named for each locality. In the last column is given the percentage of injury done by the species that was most destructive in each locality.

Table III. — Relation of Insect Ravage to Iris Habitat.

Loc.	Exposure to Sun.	Water.		Insect Enemies.						Highest Percentage of Injury.
		Amount.	*Temperature.*	*Mon.*	*Pen.*	*Mam.*	*Ars.*	*Orth.*	*Chæ.*	
1	Open	6 inches	Warm	3	4	1		2		10
2	"	1–6 "	"	2	3	1	5	4	6	30
3	"	4 "	"	3	4	1	6	2	5	40
4	"	6 "	"	3	4	1	2	5	6	60
5	Overtopping sedges	Wet soil		5	6	2	3	1	4	60
6	Deeply shaded	0–20 inches	Cold	1						45
7	Open	0–4 "	Cold (spring)	1	4	3		2	5	50
8	"	Moist soil							1	100

So the blue flag is growing in certain native habitats now, under altered conditions, apparently not normal to it, in which it meets with enemies against which it is not fitted to cope.

VIII. Alteration of Environment.

The blue flag has been less disturbed by the progress of civilization than most native species. Wild trees and shrubs and flowers have been uprooted, and cereals and forage crops planted in their place, for the farmer coveted their fields. But the Iris grows in wet places, not at once available for tillage. Yet it has suffered, both directly and indirectly; directly, through artificial drainage, drying up its native shoals; indirectly, through the influence of the change upon insects affecting its life history. It would be worth much to know, for the sake of comparison, what its relations to insects were before the white man came. In the absence of such certain knowledge there are facts of ecological adaptation which may justify an opinion as to some results of the change. To "civilization" I am inclined to attribute the following phenomena:

1. *The Destructive Abundance of Chætopsis ænea Wied.*—This species is an habitual enemy of the coarser, succulent grasses and cereal grains,[1] boring in their stems. Successive broods could not be maintained on the Iris, but the cultivation of corn and oats affords it almost unlimited opportunities for multiplication. A neighboring cornfield of the preceding year may well have furnished the swarms that devastated the Iris in locality 8. The scattering growth of the native coarser grasses in this region would not be likely to yield such swarms any season.

2. *The Injury locally wrought by the Grasshoppers.*—These were all field and meadow loving species, such as have doubtless become much more numerous in this region since the cultivation of their food plants was begun. Partial drainage, bringing the forage grasses and the flag clumps into closer proximity, would encourage the attack.

3. *The Nectar-Stealing of the Pamphilas.*—The constant presence of large numbers of these butterflies, so well adapted for another type of flower, upon the Iris, which is so well adapted to another type of insect, furnishes an example of

[1] *Vide* Howard, L. O. An Ortalid Fly Injuring Growing Cereals, *Insect Life*, vol. vii, pp. 352–354 (Fig.), 1895.

marked unfitness where nature generally shows the finest adaptations. "Civilization" may well be held responsible for this. The larvæ of the pamphilas feed on grass, and meadows and pastures have greatly increased the amount of grass available for their food. The butterflies, on the contrary, feed only on the nectar of wild flowers; these have correspondingly diminished in number; and the supply of nectar available for so specialized an insect has become very scant. They visit the Iris, because "stern necessity compels." They are equally abundant about the flowers of *Geranium maculatum* Linn., which blooms at the same time, and about every other species from which they can get any nectar. Were enough nectar available in flowers adapted to them, I think it quite likely that they would leave the Iris flowers unmolested.

I could not satisfy myself as to whether the apparent scarcity of the finely adapted bees (the only insects for which the nectar of the blue flag is made entirely available) was due to the diminishing of the nectar stores by the pamphilas or to some more remote cause effecting a decimation in the actual number of bees. But they were few about the flowers at the most favorable times; and the foregoing tables have shown the ovules incompletely fertilized.

I trust I have shown in the foregoing pages that the flower should be studied as only one factor in the reproductive process, its pollination, one of the links in the chain of circumstances, binding together two generations. It should be studied (1) in relation to local fauna and flora, (2) in relation to latitude, season, and situation, and (3) in relation to changing conditions of environment. Past studies of flowers and insects, though very numerous, are only complete in having completely demonstrated the interdependence of these and in having shown the existence of numerous coadaptations between them. There are broader ecological adaptations yet to be worked out, which may explain the fitting of a species to its place in natural society, but which will certainly require the coöperation of students, in various places and for a long time, content to spend much labor in gathering and correlating ecological data.

NOTE. — For help generously given me in the determination of the names of the insects mentioned in the foregoing paper I am indebted to a number of gentlemen, as follows: Coleoptera, Mr. Samuel Henshaw; Microlepidoptera, Professor C. H. Fernald; other moths, Professor John B. Smith; Hesperidæ, Mr. John Healy; Apinæ, Professor Charles Robertson; and, through the kindness of Dr. L. O. Howard, the following from the division of entomology of the Department of Agriculture: Hymenoptera, Mr. W. H. Ashmead; Diptera, Mr. D. W. Coquillett; Hemiptera, Mr. O. Heidemann.

A CONTRIBUTION TO THE NATURAL HISTORY AND DEVELOPMENT OF PENNARIA TIARELLA McCR.

CHARLES W. HARGITT.

I. Introductory.

The observations of which the following paper is a summary have been carried on during three summers at the Marine Biological Laboratory, and in part at the laboratory of the United States Fish Commission, from the directors of which I am very glad to acknowledge many courtesies and facilities for prosecuting the work.

The circumstances attending the work have been so varied during the years of its continuance that it may be hoped most of the errors liable to hasty observation have been avoided, and to a considerable measure the error liable to the personal equation of prepossession, where time is not allowed for its elimination.

Pennaria tiarella McCr. was first described by Ayers ('52), under the name of *Globiceps tiarella*, who has summarized its generic characters in substance as follows: Polypodon rising from a creeping root, branched. Short stems from the branches, supporting each a single polyp. Polyps encircled by three rows of arms, basal, median and near summit; the arms of the upper rows ending in globular heads. Polyp not retractile in tube. The name of the genus, Globiceps, from the peculiar form of the arms. The specific name from the number of the rows of arms. He gives no account of its distribution, except to mention that it has been taken at Sag Harbor and in Boston Harbor. Of its habitat he merely mentions that it occurs on fucus or similar substratum.

It was later described by Leidy ('55), under the name of *Eucoryne elegans*. McCrady ('57) was the first to recognize its true affinities with the Pennaridæ and designated it by the

name under which it is now known. L. Agassiz early pointed out nomenclatural objections to the name Globiceps of Ayers, and Eucoryne of Leidy, and at the same time indicated certain differences between the diagnostic characters of this hydroid and those originally designated as distinctive of the genus by Cavolini and Goldfuss. A. Agassiz ('65) in the catalogue of the North American Acalephæ has, however, followed the designation of McCrady, and has in turn been followed by most American students of the Hydroidea.

Still later, however, Allman ('71) took up the suggestion of the elder Agassiz concerning the unavailability of the generic terms Globiceps and Eucoryne and, discrediting the contention of McCrady as to the identity of the form with that of Pennaria, proposed the new generic name Halocordyle. He bases his claim for such distinction wholly upon the apparent difference as to the arrangement of the arms, or tentacles, those of the hydroid under consideration being distributed in verticillate whorls about the hydranth, while those of *Pennária gibbosa* have them somewhat promiscuously distributed over the body of the polyp.

It might be sufficient warrant for doubt as to Allman's contention that his diagnosis is based chiefly upon published figures of the hydroid, having in neither case had access to living specimens. And when added to this there is recognized the further fact that a careful study of several species from different regions, and from the same region, shows all degrees of intergradation in these respects, an unhesitating dissent from Allman's view will not be regarded as extravagant.

II. Material and Methods.

The material chiefly used was obtained at Woods Holl during the summers of 1897, 1898, and 1899, and in almost unlimited quantities. Material of P. Cavolini was secured and preserved by the writer from the Bay of Naples in 1894, and was used in many points of comparison, as will be indicated in appropriate phases of the paper. In general, collections were made at low tide and in the waters in and about the harbor,

from eelgrass, piles of the Fish Commission docks, and from fucus and rocks in the shallowed waters in and about the rocky outlet of the "hole." Material specially for the developmental work was usually collected, when convenient, during the later afternoon, so that no considerable time should elapse before the discharge of the eggs. When by reason of tides this was not practicable, collections were made at other hours, and the material placed in floats off the exposed sides of the docks, where conditions of water, temperature, etc., would be as nearly normal as possible. Experiments, however, showed that this precaution was not essential, no apparent differences being distinguishable between collections brought to the laboratory aquaria and those floated outside.

For killing and fixing, many methods were tried, but without that marked preferential distinction for one or a few which is often found for other material. Almost any of the standard fixing agents will give fairly good results. If any preference is assignable, I should give it to the stronger solutions of Kleinenberg's picro-sulphuric acid, or picro-acetic, in which the acetic acid was often used in a solution as strong as 10 per cent. The various corrosive solutions gave results of about equal value, and for carmine staining was specially good. Perenyi's fluid gave fairly good results, though less certain than the others. Flemming's fluid, while affording admirable fixation, rendered subsequent staining so difficult as to make its value secondary.

For surface study of the eggs, out of a very large number of experiments with numerous staining agents, only one gave results of sufficient value to be worth record, namely, Conklin's picro-sulphuric-hæmatoxylin, and this, when compared with results upon such eggs as those of Mollusca, was quite inferior, though enabling one to distinguish definitely considerable of the internal organization of the egg from surface views. In no other egg, save that of Eudendrium, have I found such difficult material from which to secure even approximately good differential staining reactions. Whether this is due to some physiological condition peculiar to these eggs, or to their peculiar opacity, I am unable to say.

III. Natural History.

Pennaria tiarella is one of the most abundant and beautiful hydroids to be found in the waters of the northeastern Atlantic coast, occurring abundantly in tide pools, upon piles of docks, fucus, etc. Its generic name indicates one of its most conspicuous features, namely, the feather-like form of the main stem and its branches, which spring laterally and alternately from either side. When growing in dense tufts or colonies this feature is often obscured in a measure or, in some cases, even lacking entirely. In size it varies greatly as found under varying conditions of environment. Under the best conditions it may have a height of six inches or even more, while under circumstances less favorable it may scarcely have a height of more than two inches.

In this connection may be noted a rather interesting and, so far as I know, an unrecorded peculiarity of habitat, namely, its occurrence during the summer under apparently two conditions, the one appearing considerably earlier and finding a habitat, as already indicated, upon rockweed, piles, etc., the other occurring later and in great abundance upon eelgrass. The latter form rarely attains the larger size given, but it matures with much greater rapidity and has apparently a much briefer period of activity, hardly covering more than about four or five weeks. It is further distinguished by a higher coloration of the colonies and the medusæ. Again, the medusæ free themselves with much greater frequency and ease, and swim much more actively. The ova of the two forms likewise show the same difference of coloration, those of the latter being a brighter orange and much more conspicuous, while those of the former are of a creamy white, with the slightest tint of dull pink.

Morphologically these forms exhibit no constantly distinctive differences. The first, from its habit in usually deeper water, and thus constantly submerged condition, does not exhibit that marked feather-like bilateralism common in the eelgrass form, which, from the fact that it often floats upon the surface and, at low tide, often lies quite exposed, would come naturally to assume the bilateral form. This fact may likewise account in

part for the higher coloration exhibited by the latter, and might naturally occasion the more rapid development of the colonies, as well as the greater activity of the medusæ, since their exposure at low tide and always near the surface would give them the advantage of the naturally higher temperature of the surface water. May it not be probable that this condition is an adaptive one for the more rapid multiplication of the sexual persons which, by their greater activity, secure a greater distribution? For it must be noted that the medusæ of the deep-water forms are much less active, in many cases never becoming free at all, and when becoming so rarely swimming actively. During one entire season I failed to detect this feature which I have since found to be a very common one. At one time I was inclined to suspect that, as McCrady had suggested (**'57**), the ova might have developed within the bell of the medusæ and emerged as planulæ, for, in more than one collection brought in during the early morning, numbers of planulæ were found among the fucus-bearing hydroids, and among the stems of the colonies themselves, while the yet living medusæ were found still attached to the hydranths. McCrady's observations may have been due in part to the fact that in many cases these deeper water medusæ do not seem to discharge the ova freely, and, since the free exposure of the ova within the bell of the medusa insures usually their fertilization, so, as a matter of course, the development follows without interruption. It is more probable, however, that his observations were due to a misinterpretation of the singular phenomena of segmentation, to be described later.

After the discharge of the ova the medusæ, when free, continue to swim about actively for a time, but soon begin to show signs of decline and rarely live beyond a few hours, sometimes twelve or even twenty-four, though A. Agassiz has recorded their living in confinement for several weeks. My own observations, however, show no confirmation of this. They rather confirm the observations of McCrady, who remarks upon the "apathetic condition of the medusa, following the expulsion of the planules."

In common with most hydroids Pennaria is distinctively a

summer organism, at least in its actively vegetative condition. I have not found records of its occurrence in flourishing condition later than November, and during several years of observation have not taken it in mature form earlier than June, though its seasonal variation may be considerable. After its more active period there is an evident decline in vigor, and later a degeneration of the polyps and hydrocaulus, and a recession of the cœnosarc within the stoloniferous hydrorhiza, followed by a period, more or less prolonged, of quiescence. This is chiefly a seasonal peculiarity, induced doubtless by coincident changes of temperature, food, etc. It may occasionally, however, be induced by conditions purely local and temporary. Colonies now and then show an evident decline for a period of varying extent and then may revive and regain their normal activity within a few weeks. In these cases no discernible cause is evident, and hence they have been designated as purely local and temporary.

Pennaria exhibits in a very marked way the phenomenon of "alternation of generations." The nonsexual, or vegetative, phase comprises the splendid hydroid features whose natural history has now been outlined. Its sexual, or medusa, phase presents an organism which Agassiz ('65) has characterized as "one of the most remarkable of our naked-eyed medusæ." In form it is elongate-oval, slightly smaller at the oral end. In Pl. I, Figs. 2 and 3, are shown adult medusæ with developing and mature eggs. Its size varies slightly, but averages about 1.5 mm. in length, and .8 mm. in short diameter.

In its natural history the medusa exhibits some very interesting features. Some of these have already been pointed out, such as the variation in coloration, activity, etc. Smallwood ('99) has observed in working out its development evidences of degenerative conditions which harmonize with some of the observations previously cited, and with similar conditions among not a few other of the Hydromedusæ, *e.g.*, Clava, Hydractinia, etc.

The medusæ mature with comparative rapidity and show a rather marked periodicity as to the time of liberation. And here again there is a rather sharp difference between the so-

called eelgrass forms and those of the deeper water habit. The former are liberated usually from about 7 to 8 P.M., followed almost immediately by the discharge of the sexual products. In the latter form the time of liberation varies from about 10 to 12 P.M. In each case the male medusæ are, as a rule, first set free, usually from a few minutes to half an hour. Fertilization of the eggs occurs at once upon their discharge.

In Pl. I, Fig. 2, is shown a mature medusa as it appears within a few hours of its liberation from the hydroid. At this time the nearly mature ova occupy almost the whole interior of the bell, often distorting in some measure its form. In no case, however, have I observed any such remarkable distortion at this stage as that described and figured by Agassiz ('**65**), and I am disposed to suspect that his specimen must have been a very unusual one, for certainly with ova surrounding the whole of the manubrium and compressing it greatly a one-sided distortion must be rather difficult to understand. As the ova grow about the manubrium they are flattened, disk-shaped bodies of an outer convex and an inner concave aspect. Approaching maturity they begin to assume a more or less spherical form, as indicated in the figure. Just prior to the release of the medusa, and perhaps induced in part by the rhythmic contractions by which this is effected, they assume a perfectly spherical form; the mesenterial membrane becomes more closely fitted to each individual egg, and at the moment of release the animal has the form exhibited by Pl. I, Fig. 3. Swimming rapidly about with the characteristic jerking movements common to these smaller medusæ, the ova are discharged one by one as the animal swims, and thus a considerable distribution is secured to the ova and the new colonies to arise from them. In the growth and maturity of the male medusa essentially the same phenomena are exhibited. The sperms closely pack the whole subumbrella cavity, but as the medusa is about to be liberated the mesentery seems to contract, and quickly following this, as release is effected, the membrane is ruptured and the sperms discharged in immense numbers.

IV. Maturation and Fertilization.

Under these heads I shall give at this time only the merest synopsis of my observations, for there are many points yet to be worked out in detail, and to these I shall give special attention in a later paper, which is, however, well under way and may, I trust, appear within the near future.

As Smallwood has pointed out ('99), and as Doflein ('96) has also shown for Tubularia, and as I have found in Parypha, the ova grow within an ovarian mass of primitive ova by the consumption of their fellows, nuclei of which may be seen in all stages of degeneration, both about and within the growing eggs. In Parypha the most perfect illustrations of degenerative metamorphosis and amitotic division are shown, and in this form they are not wholly disintegrated during the process of segmentation of the egg, nor even till after at least the ectoderm of the larva is very clearly established.

As the egg grows the nucleus migrates toward the periphery, becomes very indefinite in form, and also seems quite indifferent to ordinary staining processes. In only a few cases have I found from surface preparations, and in observations upon the living egg, any clear examples of polar bodies. However, the fact that the ova are devoid of membrane and are peculiarly opaque would naturally obscure or render quite transient these bodies. The ova are of relatively large size, varying from .4 mm. to .5 mm. in diameter, and heavily yolk-laden, and, as already indicated, vary in color from a creamy white with faint trace of pinkish hue to a clearly orange color.

Fertilization occurs very soon after the ova are discharged from the medusa, and hence only external, unless, as indicated in another part of the paper, where, after the velum is ruptured as well as the mesentery suspending the egg, fertilization may readily take place within the bell cavity. A number of experiments and observations have demonstrated this quite conclusively. Artificial fertilization is quite easy and can be controlled at will. Very soon after extrusion of the egg, sperms may be seen surrounding it in great numbers, in some cases completely covering it and adhering for some time. The

entrance of the sperm produces a profound effect upon the egg, which up to that time has been quite passive. Examined under a low power the egg very soon after access of the sperm shows a sort of convulsive surface torsion, which after a few minutes quite disappears, and the egg again becomes quiescent. But within half an hour, often sooner, the phenomena of cleavage begin and usually go forward with comparative rapidity, the entire process, so far as surface features are concerned, becoming complete within a few hours, though varying greatly in different eggs and under slight differences of temperature.

V. Cleavage.

Of cleavage phenomena in Pennaria it is extremely difficult to formulate an account, and that for several reasons. A glance at the figures which present only some of the more striking aspects of the subject will afford one, and perhaps a sufficient, reason. Again, the unusual opacity of the eggs renders difficult, either in the living or preserved material, any critical insight into other than the surface phenomena. There seems to be no law or order attending the process. Every egg is a law unto itself and is absolutely indeterminate as to order or rate of development. Beyond the accounts of Wilson for Renilla ('**84**), and Metschnikoff for Ratkea and Oceania ('**86**), the literature at my command affords nothing comparable, and these are only remotely so. Andrews ('**98**) points out "Some Ectosarcal Phenomena in the Eggs of Hydra," which, while in some features they are similar to some aspects associated with these phenomena in Pennaria, seem yet to be of a decidedly different character. Similar ectosarcal features were more or less obvious in the eggs of Pennaria, bits of protoplasmic matter at times being extruded and even detached from the surface of the egg, including at times considerable portions. Again, the presence of more or less definite protoplasmic bands, or bridges, during the earlier phases of cleavage is a very conspicuous feature in Pennaria. That it may in some way be associated with fertilization, the entrance of several Spermatozoa, artificial conditions, or otherwise, would seem not improb-

able. The highest powers of the microscope revealed nothing which seemed quite comparable with the so-called spinning movements of protoplasm, to which Andrews has directed attention.

So anomalous are these phenomena that during the first several series of observations the conclusion was unavoidable that they were strangely abnormal or, perhaps, pathologic. Accordingly, the first series were wholly discarded, except a few specimens which had been isolated in watch glasses and set aside more out of curiosity than otherwise, and left overnight. An inspection the following morning revealed several apparently normal larvæ. The observations of the following night were to the same effect, though at this time a considerable series of all sorts were isolated with pains to eliminate possible error, and with results quite assuring, in that in a very large proportion of the cases perfect larvæ resulted and continued to develop. Following this, systematic collections were made and painstaking observations and records kept of every feature associated with development.

Occasionally an egg would segment with a fair degree of regularity into the two, four, and eight cell stage, as shown in Pl. II, Figs. 7, 8. But beyond this point it was difficult to follow any order in the cleavage, though it might continue with more than ordinary regularity as compared with the average of its fellows. It was utterly impossible to trace anything like a definite lineage of cells, notwithstanding repeated and careful attempts. By no means was it possible to predict the direction or course or rate of any division beyond the first or second phase of the cleavage, and even then only occasionally.

While Wilson ('84) has noted a considerable degree of individual variation in the cleavage of Renilla, he is still able to reduce it to some half dozen types. With Pennaria, however, while it is possible to recognize some few rather predominating types in the earliest cleavage, as, for example, a centripetal, a centrifugal, and a vertical, yet they are not of sufficiently pronounced character to constitute well-defined types which are distinguishable as such. In no case were there any clearly defined and symmetrical equatorial phases recognizable, though

occasionally incipient aspects of it were detected. This may be due in part to the membraneless condition of the eggs, but perhaps rather to their more or less evident amœboid condition, which asserted itself in the earlier phases. Again, the eggs early became somewhat flattened and disk-shaped, and only as the external phenomena of cleavage were completed did they resume an approximately spherical form. In Pl. II, Figs. 1–6, are shown a single series of cleavage phases noted at intervals of ten minutes or less. All were sketched from life by the aid of a camera, and, as will be noted also, there are presented only the *earlier* phenomena. As segmentation progressed its superficial aspects became less and less evident, owing to the opacity of the eggs, and only in a few cases were attempts definitely made to follow it to anything like completion. In these and other figures will readily be recognized the amœboid aspects referred to above.

Reference has been made incidentally to the variable rate of segmentation. This feature was quite as marked as were others, both as to individual eggs and blastomeres. In many cases a single blastomere would divide at a rate quite phenomenal, so that it was difficult to sketch adequately successive phases, while others might remain in a state of inaction for an indefinite period or even be engulfed bodily into the more rapidly segmenting portion. Then, also, in many cases cleavage seemed to begin in a somewhat discoidal fashion at a single pole and only gradually extend to other portions, as shown in Pl. IV, Fig. 1. This could hardly be due to any marked inequality in the distribution of the food yolk, for in this respect the eggs of Pennaria seem to be quite isotropous, and indeed there seems little if any definite polarity of any sort evident in these eggs. Occasionally, as shown in Pl. IV, Fig. 1, cleavage appeared to advance from a single area, but in the large proportion nothing of the sort was evident, and, as Conklin ('97) has shown in molluscan eggs, where the greatest variation in matter of yolk distribution is distinguishable, there is none the less a perfect symmetry of rate and character of cleavage. This would seem to be only another illustration of the inadequacy of any known law as an explanation of all cleavage phenomena.

That these are really cleavage, and not merely amœboid phenomena, can hardly be matter of serious doubt, even when considered from the more superficial phenomena already presented. If, however, other evidence were needed, it is available in the greatest profusion from sectional sources, portraying the internal structure and organization of the egg. In Pl. IV, Figs. 1–6, are shown camera sketches, of a few sections only, of eggs in different stages of segmentation. That they are clearly correlated in general features with the superficial features already noted there is no doubt whatsoever, though there may be many points of detail which need attention, but which can only be touched upon at this time. That Pl. IV, Fig. 2, is comparable with that of Pl. II, Fig. 7, as a two-cell stage must be obvious at a glance. There are, however, here some interesting facts to which a moment's consideration may be directed. It will be seen, for example, that there are present, in the section, portions of several nuclear figures, a somewhat unusual condition at this stage of development. However, here again there is something in common with what Wilson has recorded in certain cases in Renilla, namely, the internal nuclear division preceding that of the cytoplasm which followed, or lagged, as it were, finally dividing at once into an equal number of cells. It is, however, quite different in that in these the nuclear cleavage seems constantly to outrun that of the cytoplasm. It had occurred to me that possibly there might be here what has been noted by Loeb ('**99**), Norman ('**96**), and others, namely, a sort of artificially produced cleavage of the nucleus, induced by some chemical or pathological stimulus. The comparison of many sections, preserved under different conditions, and by different methods, however, leads me to conclude that it is a perfectly normal condition so far as these particular eggs are concerned. I have also observed the same thing in the eggs of other hydroids, and Hickson ('**93**) calls attention to a similar condition in the cleavage of Allopora. It would seem as if from some cause, not perhaps easily distinguishable, that all the phenomena of cleavage in some of these organisms have been greatly modified, that in some way the nucleus and cytoplasm have, as it were, been thrown out of concord, and their

rhythmic relations disturbed to such an extent that this very erratic and anomalous type of segmentation has resulted. May it not be within the line of possibilities that the peculiar methods and conditions of growth and maturation of these and some similar eggs have in some way been the occasion of the disturbance? While only a suggestion, yet it seems not without the range of possibilities.

In Pl. III, Figs. 1–7, are shown conditions not uncommonly met with, which are specially interesting in that from one such were derived spontaneously two perfect embryos, a fact, so far as I am aware, quite unusual, if not unique, though Metschnikoff ('86) cites a somewhat similar case in the development of *Oceania armata*. It does not seem clear, however, from his account whether the cases are quite similar, certainly not in the details of the cleavage. Following the first cleavage in these eggs, during which the blastomeres become widely separated, the two halves proceed to develop quite independent of each other and show no disposition to reunite until the cleavage is quite advanced, apparently to the point of completion or nearly so, when usually they gradually approximate and finally fuse into a typical morula and develop into a normal embryo. In at least one case a specimen which showed this aspect in a very marked degree at an early stage gave rise to two perfect larvæ, though of small size. The specimen was carefully isolated in a large watch glass and set aside as a test case, and the next morning the larvæ were found in perfect condition, as indicated. Several others of similar character were subsequently isolated in the same way, but in only the one case did this spontaneous division show itself conclusively. That such cases, though rare, are not strange among these organisms may be very well conceded, specially when the peculiar phenomena associated with the early development are familiar.

VI. Completion of Segmentation and Formation of the Planula.

Following the more conspicuous and anomalous aspects already considered, the egg gradually assumes a nearly spher-

ical form, hard to distinguish from the freshly discharged ovum, almost all surface aspects of cleavage having disappeared. In this form it remains apparently quiescent for some hours, during which time, however, internal cell division goes on quite actively, as sections clearly show. With completion of this internal cleavage the embryo becomes a solid morula, with only the faintest indications of any differentiation into an ectoderm (*cf.* Pl. IV, Fig. 6). Following this, however, the specialization of an ectoderm soon takes place, and the embryo begins to assume the characteristic pyriform, or oval, shape of hydroid planulæ. Within from twelve to twenty hours cilia make their appearance over the ectoderm, and the free life of the larva is assumed. Up to this time, however, and for some time after, no definite endoderm has been formed; the entire mass of internal cells seem scarcely distinguishable from each other, except that near the central portion the remains of yolk débris are more or less apparent. It is not till after some hours of larval life that an endoderm is gradually specialized from the internal cell mass and takes on an appearance quite similar to that of the forming ectoderm. After the establishment of the diploblastic condition there still remain a mass of undifferentiated cells, intermingled with yolk granules, which seem gradually to disintegrate and are consumed as food by the developing larva, which, up to the polyp stage, is wholly without mouth or other means of taking solid food, though in all probability absorption of water with soluble matter in small proportion takes place.

The larval history of Pennaria seems considerably longer than the corresponding period of many other hydroids. In several cases specially noted the planulæ did not settle for attachment and transformation till some five days following the beginning of development, and only at the end of seven days were tentacles well marked, as shown in Pl. III, Fig. 10. The tentacles originate by a process of budding, the lower, or filamentous, series appearing first, those of the other series following somewhat later.

Secretion of the perisarc begins almost at once after the attachment of the larva, preliminary to transformation. At

first it is an exceedingly delicate, almost indistinguishable, transparent film about the base of the polyp. This gradually thickens and soon hardens into a sheath about the growing polyp, covering at first the entire larva. Annulation of the perisarc seems to occur at no very definite time or place in its growth. In some cases it is apparent almost from the first. In others it only becomes apparent at a considerably later time, and nearer the hydranth than the base. As to the significance of the annulations, either in origin or function, nothing very definite can be said. That the perisarc itself is a protective adaptation seems almost beyond question; but whether the annulations characteristic of this and many other hydroids is an additional adaptation, rendering the stem flexible, etc., may be doubtful.

VII. Abnormalities.

The eccentric forms of cleavage already considered naturally raise the question as to probabilities of corresponding anomalies among the larvæ of these forms, and also of the resulting polyps; whether at any rate any variation appears from the normal type of embryo. The answer in part may be inferred from a glance at Pl. I, Figs. 4–6. These represent but three out of a considerable number of eccentric forms observed during the progress of the work. As will be seen, Fig. 4 represents what might be designated as a twin planula, having a rather broad and blunt anterior and a bifurcated posterior. In Fig. 5 is represented a second type, quite common, which differs from the former chiefly in the shape of the body of the embryo, which is somewhat spindle-shaped, and also in the slender and attenuated character of the posterior bifurcated portions. In Fig. 8 is shown a third type which is somewhat unusual. The body portion is decidedly eccentric in shape, with irregular tentaculate processes arising from it at various points and of various sizes and shapes.

Whether such anomalies occur to any extent under perfectly natural conditions, of course, cannot be said. But from their occurrence under the most favorable conditions in aquaria, and since, moreover, they seemed in no way to interfere with subse-

quent development, it may be inferred that their occurrence in a state of nature is not in the least improbable. Similar abnormalities have been reported among other genera of hydroids, *e.g.*, Bunting ('**94**) figures embryos of very similar character. Now whether all such anomalous planulæ develop into normal polyp may not be easily determined. That many should not is only what constantly happens with the most typical. That some of them develop there is not the slightest doubt. In Fig. 6 is shown a specimen which had become fixed in the ordinary way and had developed tentacles upon apparently two polyps heads. And in this connection it may be noted that in many cases these anomalous processes have been seen to be resorbed into the body of the larva as it approaches the period of transformation. This may suggest that they are perhaps only temporary processes which may serve some temporary function of doubtful significance. The larva shown in Fig. 4 might suggest that it had its origin as a twin from a single egg which had segmented somewhat as represented in Pl. III, Fig. 4, where development of the two halves of the ovum had gone on so apparently independently. But in no specific case, several of which had been isolated and watched with care, had any such form resulted. Nor, further, in specimens of similar larvæ carefully sectioned was there any special evidence of such an origin.

I am rather disposed to consider them as due in all cases to the intrinsic prepotency of hydroids to bud and branch; for, as I have repeatedly observed, and as Pl. I, Fig. 8, will show, the budding propensity asserts itself very early in the polyp life.

Concerning abnormalities among adult hydroids of this genus I have made no extended observations. Bunting ('**94**) refers to several cases among Hydractinia and Podocoryne. But in these the polymorphic conditions would, it seems to me, render them specially favorable subjects in which to expect such divergencies, while in Pennaria, at least, this element is lacking.

In Fig. 1 of the text is shown a somewhat unusual, though possibly not abnormal, young polyp. As will be noted, its unusual feature consists chiefly in the total annulation of the

stem, including the branch. This is in rather striking contrast with those figured in the plates and in the well-known annulations of the stems of the Pennaridæ. I was for a time constrained to wonder whether this might not have been a specimen of some other genus which had accidentally been brought in with the collections and had developed along with the Pennaria. Such a supposition is not impossible of course, yet the general aspects of the hydroid are so peculiarly pennarian, the annulations excepted, that I am rather constrained to regard it as simply a specimen which exhibits, in an unusual degree, a phenomenon which in itself is one of the most variable among hydroid characters, and that it shows how unreliable must be such a character for diagnostic purposes.

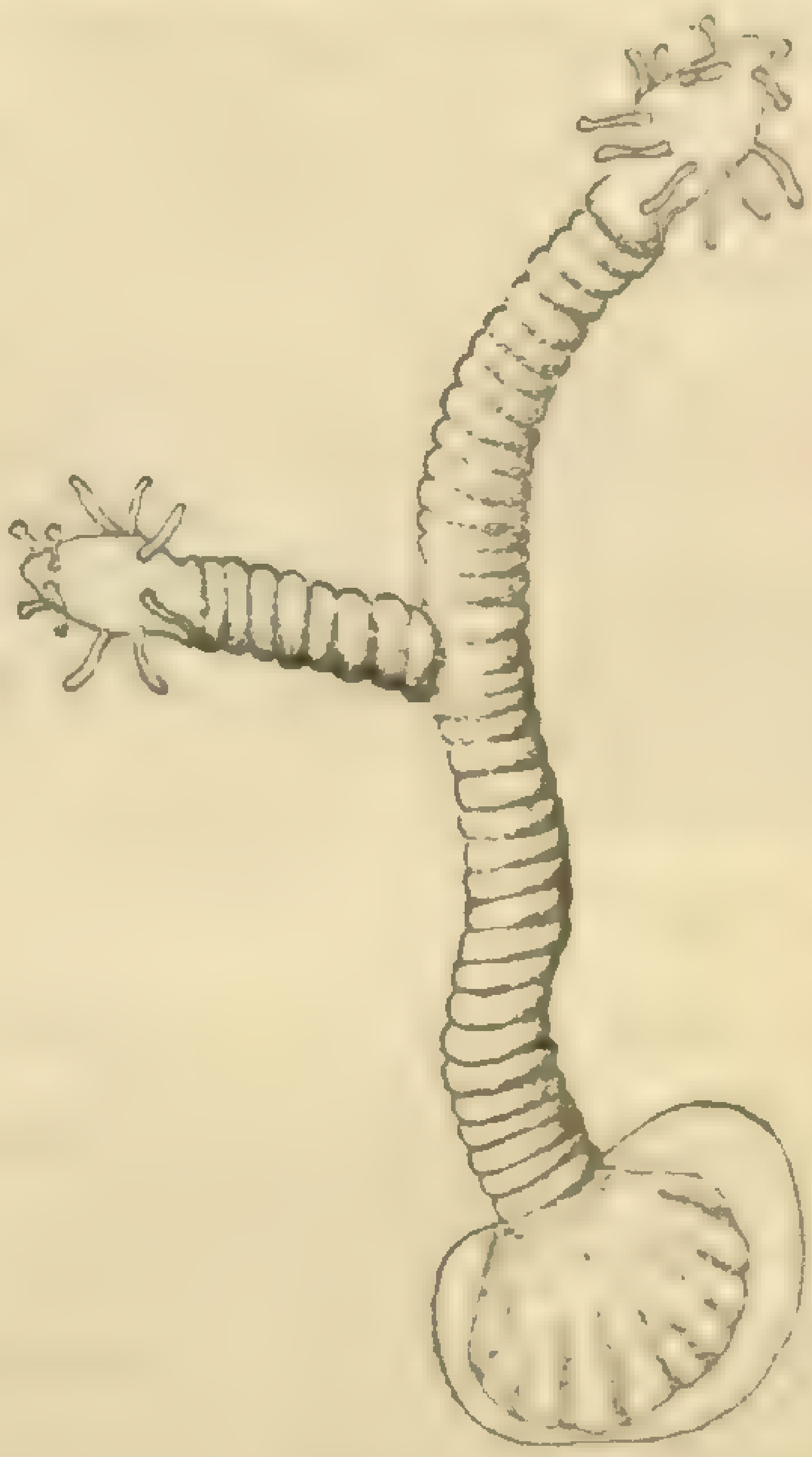

FIG. 1.

VIII. Experimental.

1. *Darkness.* — The liberation of the medusæ and the discharge of the sexual products upon the approach of darkness suggested this as a possible cause of the unusual activity at this time. Accordingly, several experiments were made to determine whether such were really the case. Colonies of both sexes were collected about 3 P.M. and were carefully excluded from light in suitable receptacles, but in no case could they be induced to discharge their products or become free at an earlier time, though that such conditions might have at some time in the life of the race been a factor in determining the periodicity of their maturity and release may not be improbable. But, as has already been pointed out, the fact that the deeper water forms do not become free or discharge the sexual products until toward midnight would certainly seem to suggest that darkness alone could not be the determining factor.

2. *Temperature.* — The observation that during specially warm weather larger numbers were liberated suggested the

possible influence of temperature upon the maturity of the medusæ, and suggested also additional experiments. Artificial change of temperature by means of heat or ice had a very noticeable effect, both upon the activity of the medusæ and the cleavage of the eggs, the reduction of temperature by a few degrees materially retarding the rate of cleavage, while raising it a corresponding amount proportionately accelerated these phenomena. This was likewise evident in the development and activity of the larvæ.

3. *Artificial Division of the Eggs.* — During the earlier phases of segmentation experiments were made to determine the effects of detaching small portions of the egg, in imitation of the observed spontaneous detachment of particles from the surface, to which reference has already been made. From repeated experiments it was conclusively shown that removal of small portions, and indeed of considerable portions, did not materially retard or modify the development of the eggs, or prevent their final development into perfect larvæ.

Again, the experiment of dividing eggs at the first cleavage, and at the second, and also of dividing them into several portions, was made in a considerable number of cases, with the results of obtaining from these fractions perfectly normal, though small, embryos, which continued to thrive and, finally, in the usual time transformed into perfectly normal polyps. Pl. III, Fig. 11, shows one of these half-egg polyps which was isolated and reared under conditions which leave no shadow of doubt as to the genuineness of the case. And this is only one of a considerable number, some from smaller portions, which were similarly secured. In Fig. 2 of text are shown a series of planulæ of normal and artificially produced specimens, in which the relative sizes are clearly exhibited.

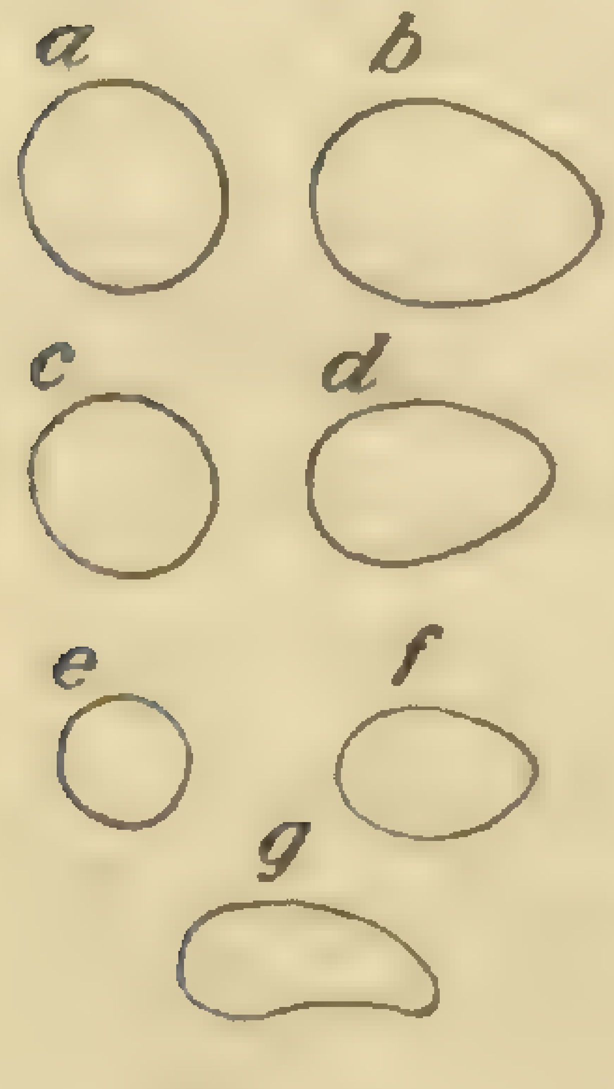

FIG. 2.

On a preceding page attention was directed to a rather remarkable feature, namely, the natural origin of two embryos from a single egg, by a spontaneous division at some point during the segmentation. These facts would seem to show conclusively that so far as the hydroids are concerned there is no such pre-

determined organization of the egg as that a given part must necessarily determine a given organ or part. For in the half or fourth embryos the number of tentacles arising in the polyp was of the same number and arrangement as in the normal one.

So, too, in the formation of perisarc, rate of growth, etc., there was nothing to indicate that the larva was other than a normal one in every respect, that of size alone excepted.

It may not be without the range of these facts to refer in passing to similar experimental work by Driesch, Wilson, Loeb, and others and to refer in particular to that which is in some respects rather unique. Concerning the capacity of portions of eggs regularly to develop into perfect embryos it is unnecessary to make special mention at this time. Loeb has shown ('93) that under the unusual stress of osmosis, induced by varying the density of the medium, double or multiple embryos of sea urchins might be produced almost at will. This has since been matter of common experiment. What seems to me of special note in connection with these experiments on Pennaria is that not only may such *experimental* results be obtained, but that similar results have been obtained in perfectly *normal* ways, that the entire phenomena of cleavage reproduce at some phase or other an almost identical counterpart of former experimentation along these lines. No one can follow the segmentation of the ova of Pennaria in its extremely variable and anomalous aspects without the conviction that there are here involved intrinsic forces, quite as pronounced as any which have been involved in the artificially operative chemical and physical agents to which reference has been made. That they may comprise much of chemistry and of physics is not questioned. But if so, they are intrinsic and integral.

Syracuse University,
March 1, 1900.

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EXPLANATION OF PLATE I.

FIG. 1. Single colony of Pennaria, natural size, showing mode of typical branching, attachment to substratum, etc.

FIG. 2. Medusa about mature, showing form of ova at this stage, mode of attachment, etc.; *ov*, ova; *rc*, radial canals; *t*, tentacles.

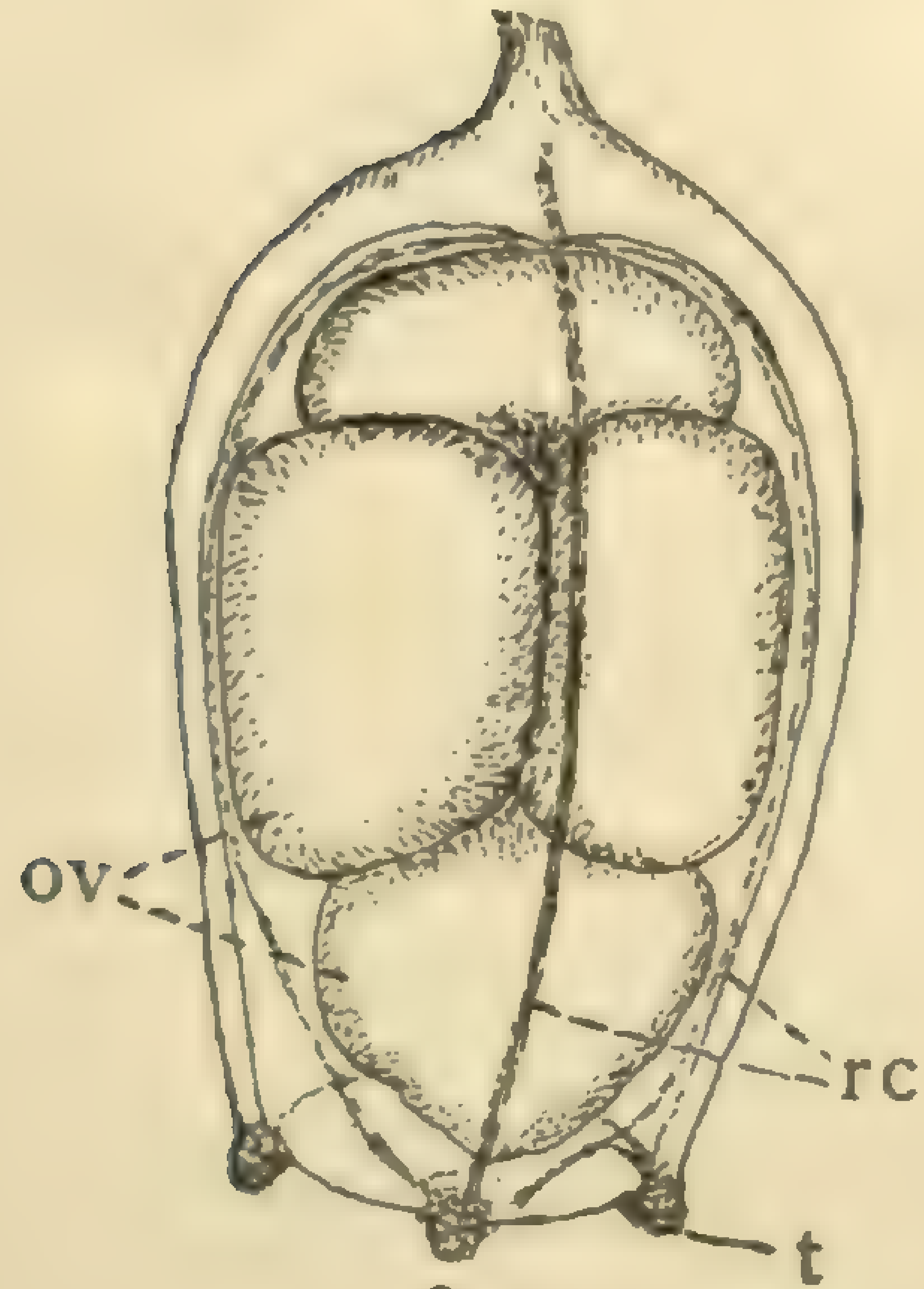
FIG. 3. Mature medusa, parts as in Fig. 2. Ova perfectly spherical, and clustered about the manubrium; *v*, velum.

FIGS. 4, 5. Abnormal larvæ, as found in several cases, showing the bifurcated condition.

FIG. 6. Rather unusual type of polyp, with small bud, *b*, on side of body, and with less than usual number of tentacles.

FIG. 7. Typical planula, about twenty-four hours after laying of the egg.

FIG. 8. An unusual larva, similar in some respects to that of polyp in Fig. 6, but with several bud-like developments, *b*, *b′*, *b″*.



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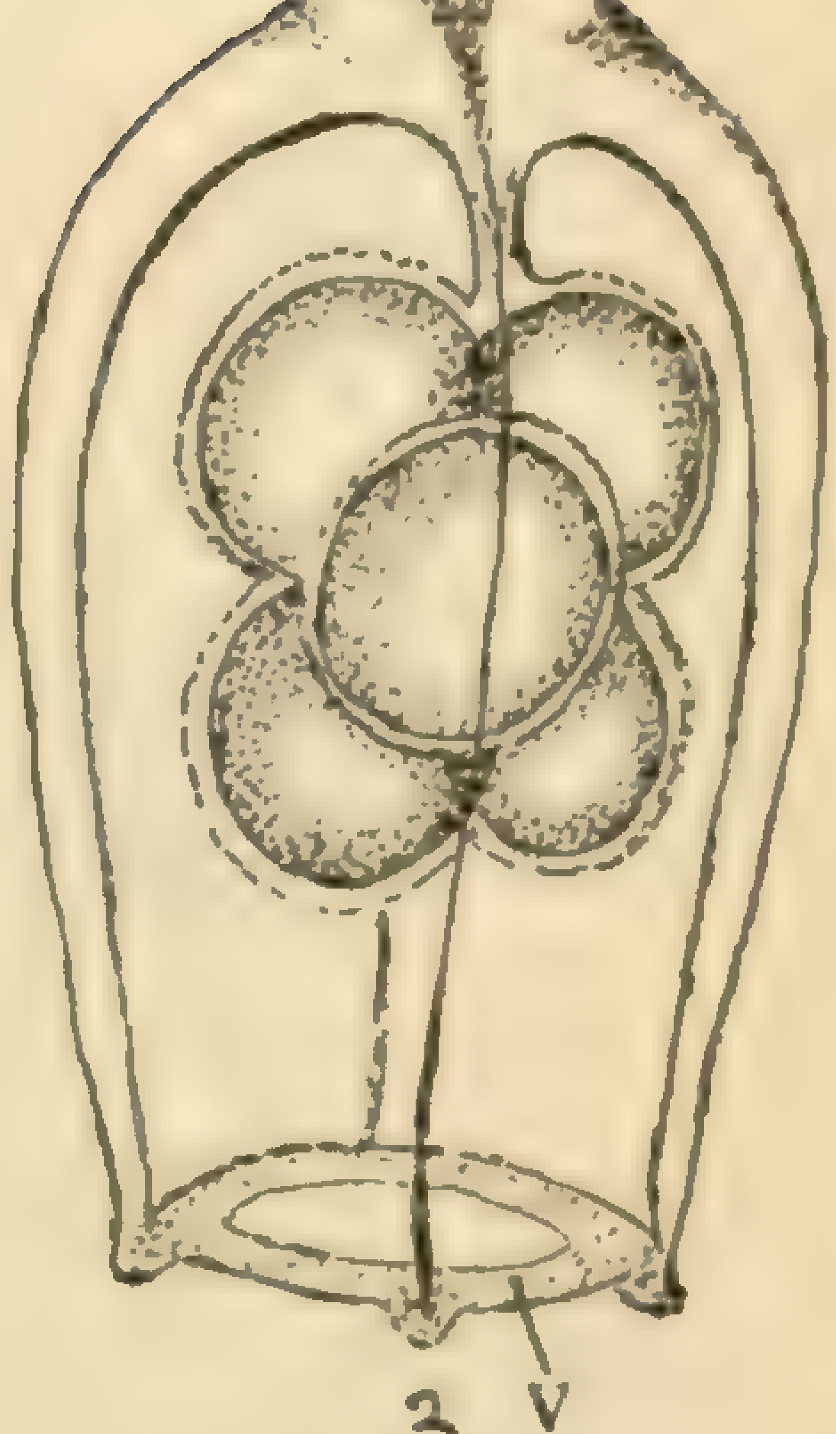

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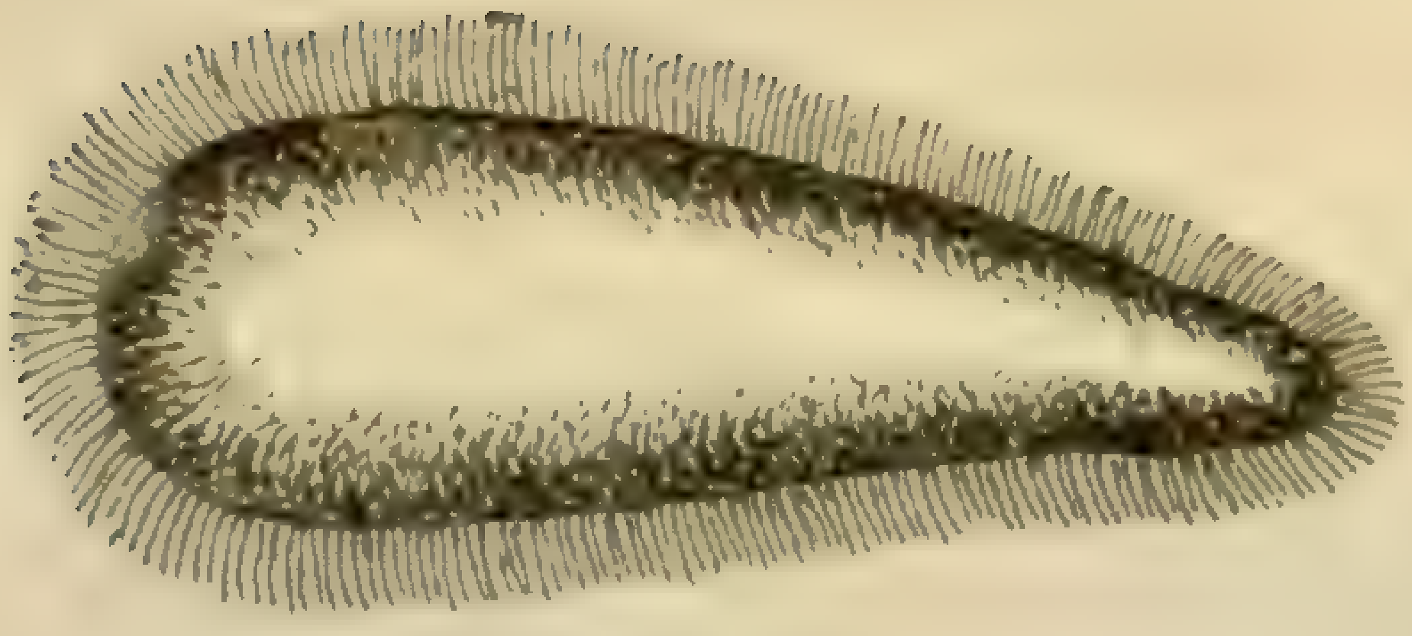
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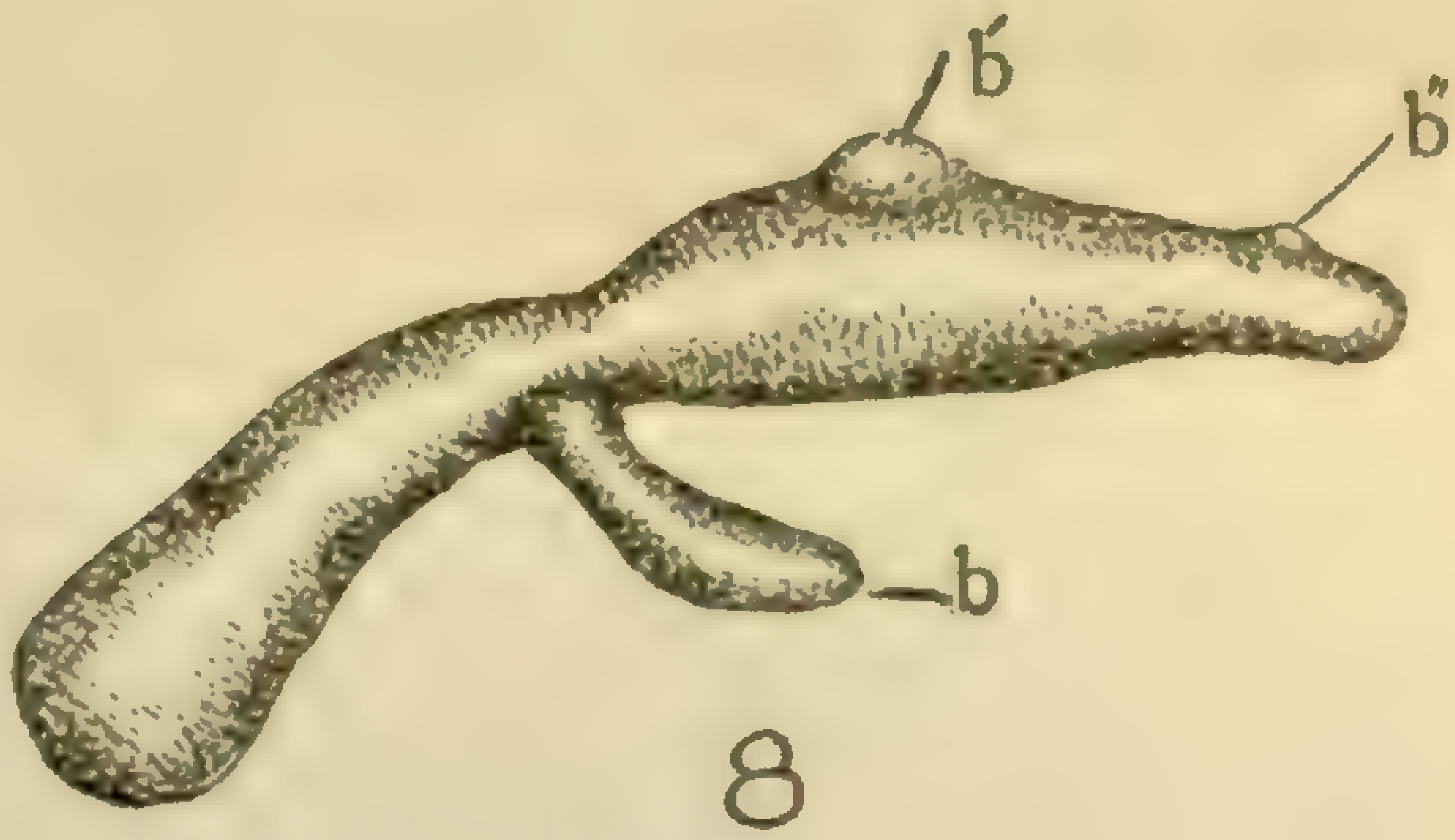

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EXPLANATION OF PLATE II.

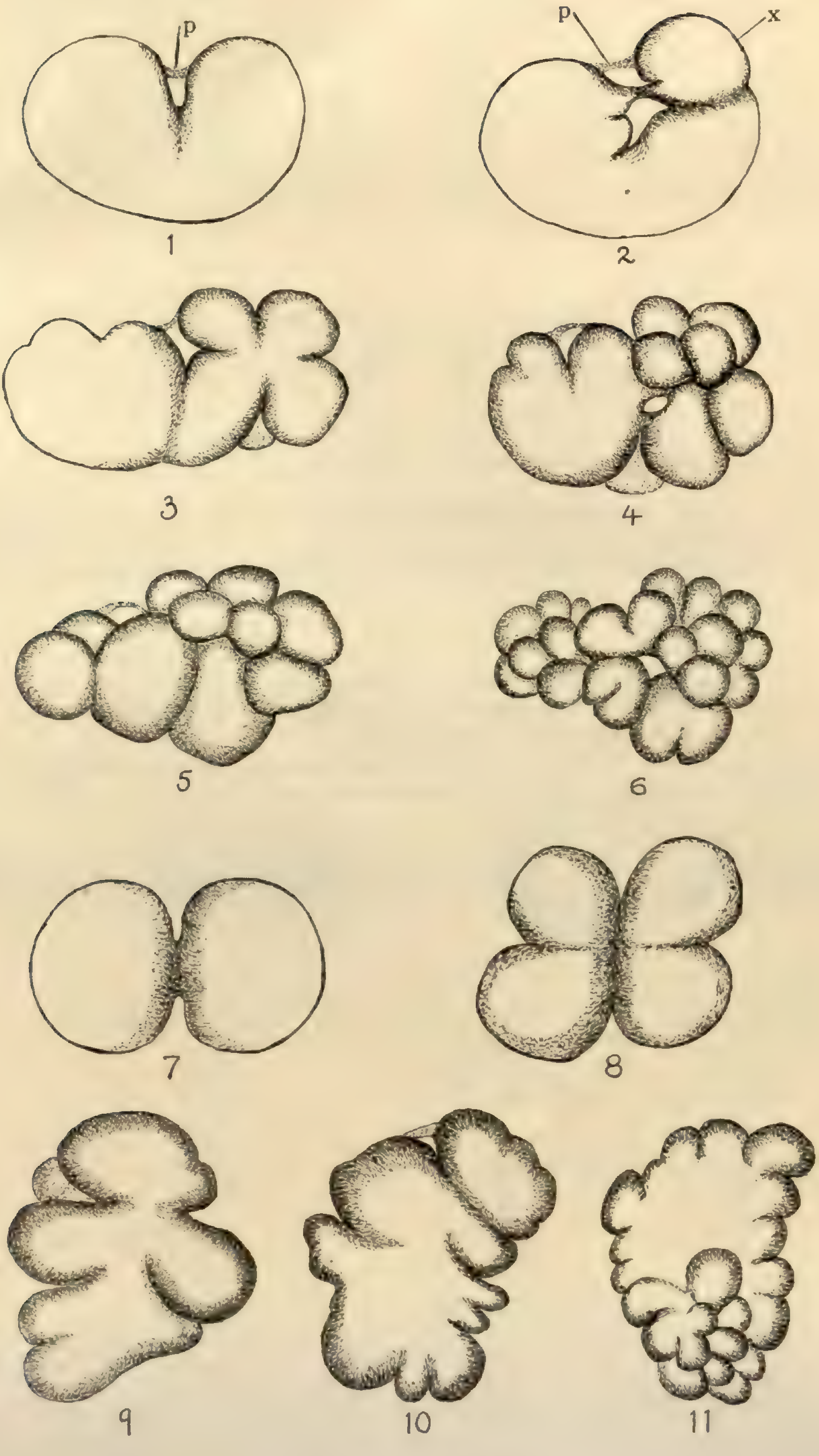
FIG. 1. Egg in first cleavage phase ; *p*, a protoplasmic band connecting the blastomeres.

FIG. 2. A second phase of cleavage, indicated by furrow cutting off a small blastomere at *x*. Two protoplasmic strands are shown, one, *p*, the same as in Fig. 1.

FIG. 3. Next phase ten minutes later.

FIGS. 4–6. Show successive phases in progress of the development.

FIGS. 7–11. Show phases of cleavage in another egg, which differ in some respects from the former, yet resulting in practically same condition.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EXPLANATION OF PLATE III.

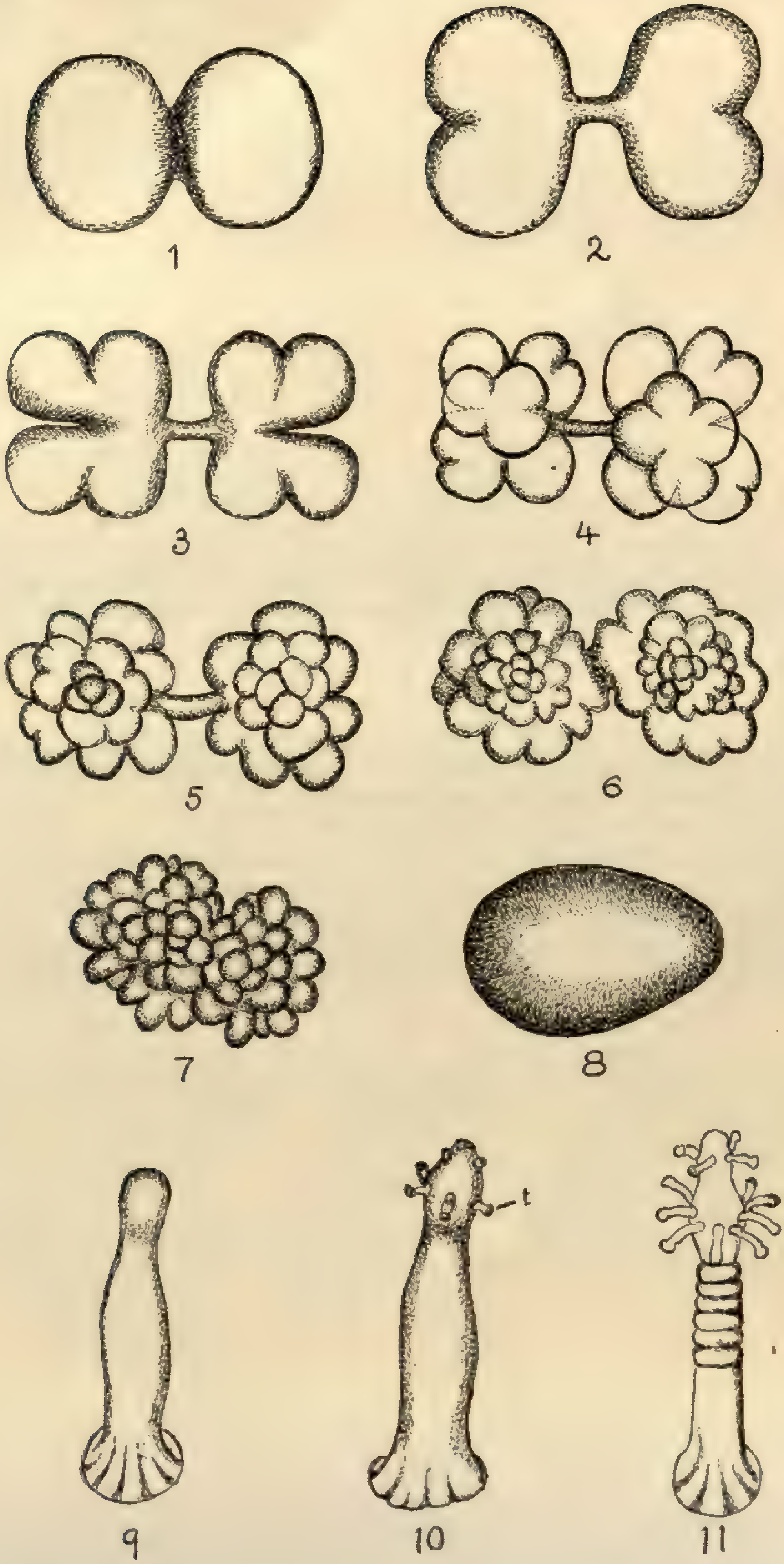
FIGS. 1–5. Show a phase of cleavage not uncommon, in which, after the first division, the blastomeres segment in a perfectly independent way.

FIGS. 6, 7. Show the final coalescence of the two portions, and in Fig. 8, the resulting morula, which gradually assumes the planula form of Fig. 7 of Pl. I. The figures of this series are somewhat diagrammatic.

FIG. 9. Young polyp phase soon after attachment.

FIG. 10. Polyp with budding tentacles, *t*.

FIG. 11. Fully grown polyp, with full complement of tentacles, mouth, annulation of perisarc, etc. Sketched from life, with camera.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EXPLANATION OF PLATE IV.

FIG. 1. Section of entire egg in early cleavage phase, showing more rapid rate at one pole, while the opposite shows a resting nucleus and no indications of segmentation. Camera sketch, × about 45.

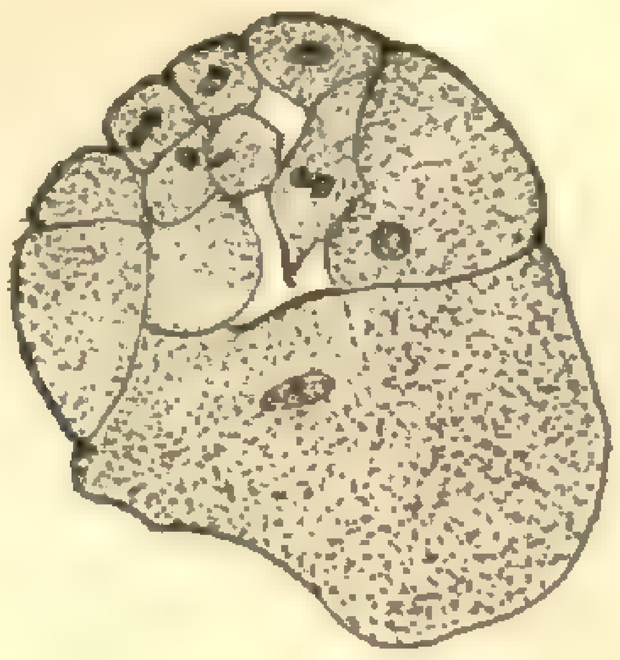
FIG. 2. Two-cell stage. At the left is shown a perfect nuclear spindle, *sp*, and in the opposite blastomere several asters, which may indicate the nuclear divisions which have occurred, without involving the cytoplasm.

FIG. 3. Section of egg, × 135, showing various internal cleavage conditions, chiefly superficial; *n*, nuclei in resting condition.

FIG. 4. Portion of egg more highly magnified.

FIG. 5. Portion of another egg, showing essentially similar conditions.

FIG. 6. Section of egg at completion of segmentation, showing a mass of nuclei partially organized into a cellular ectoderm, *ec*.



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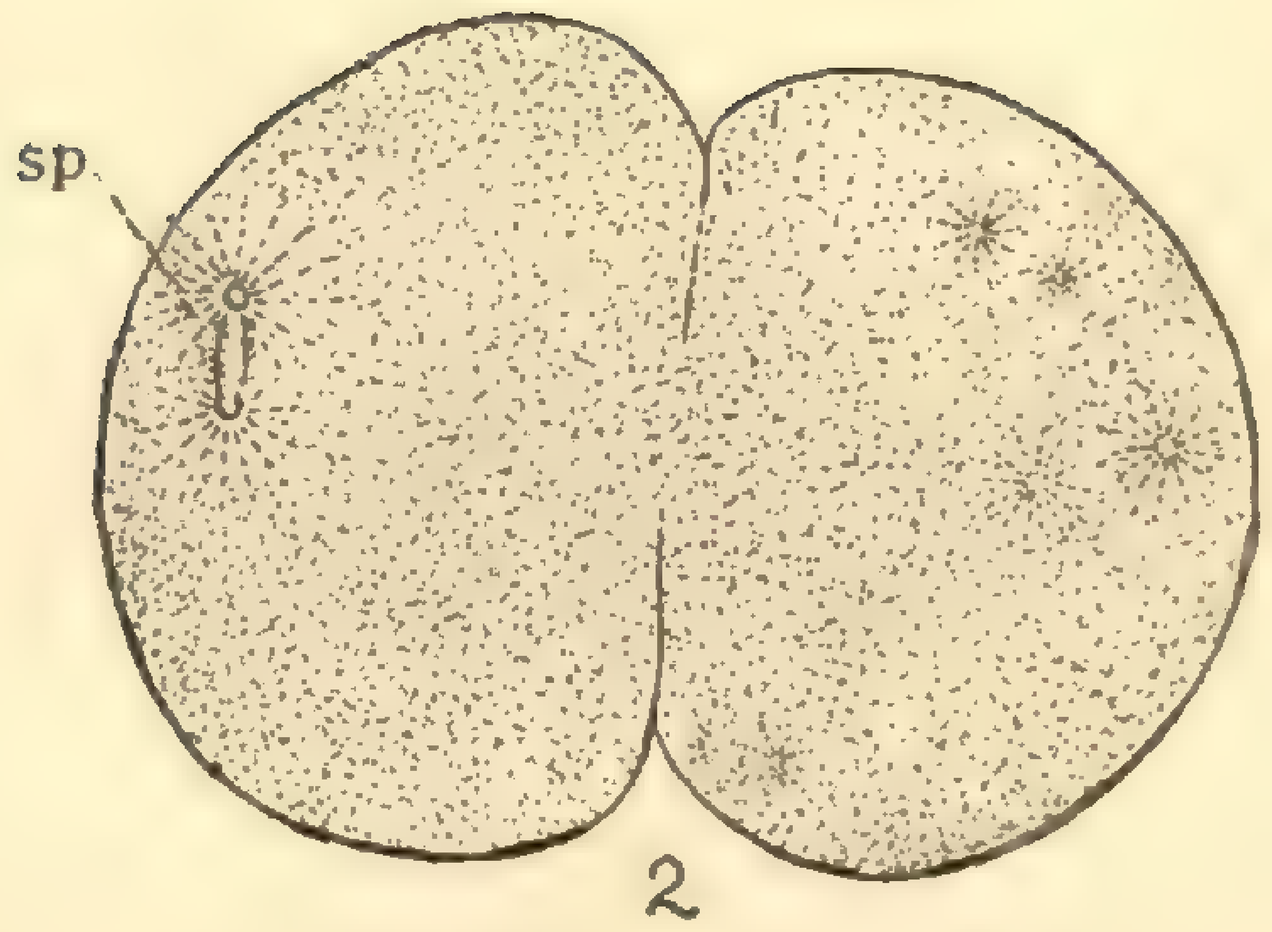

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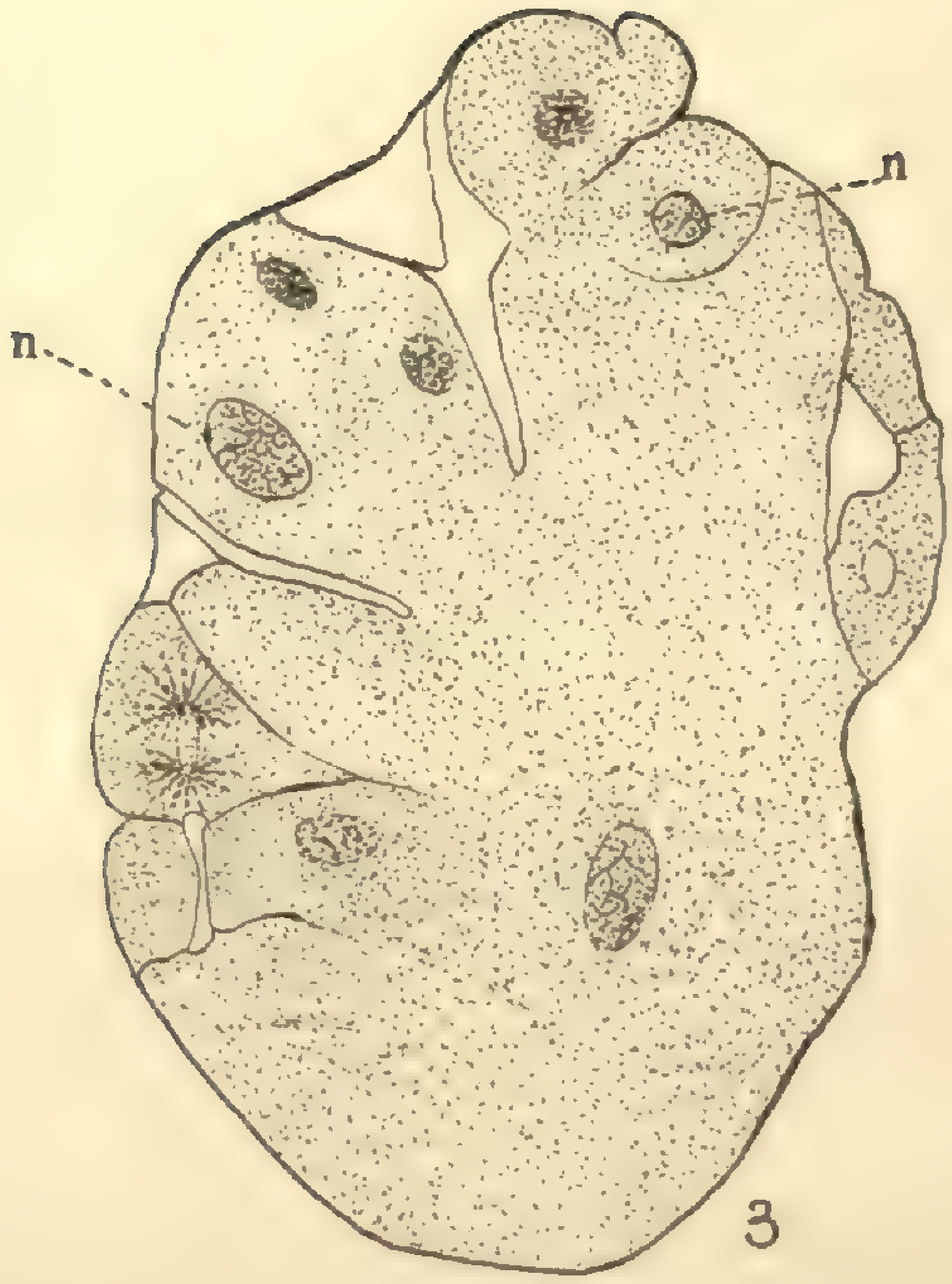

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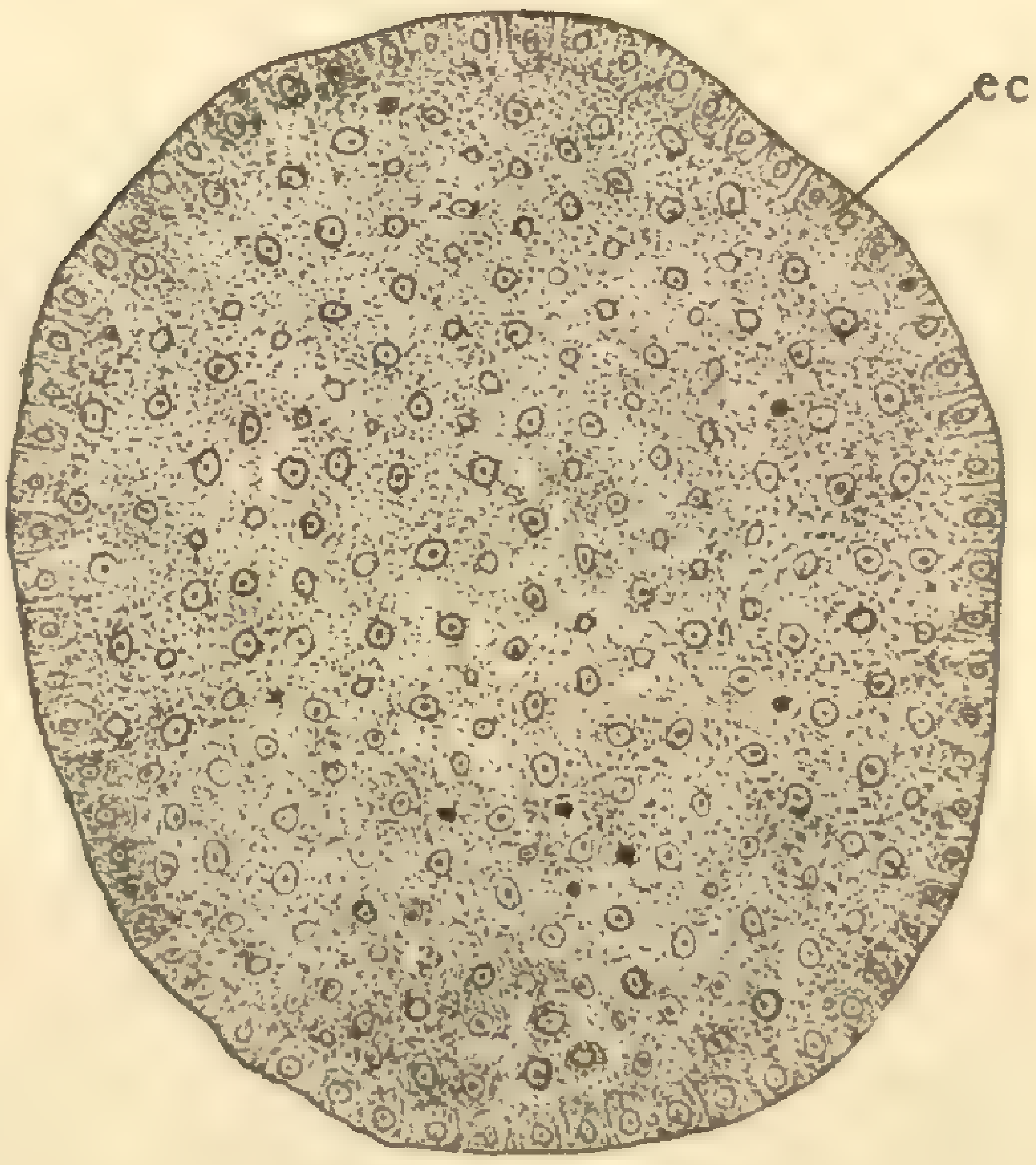

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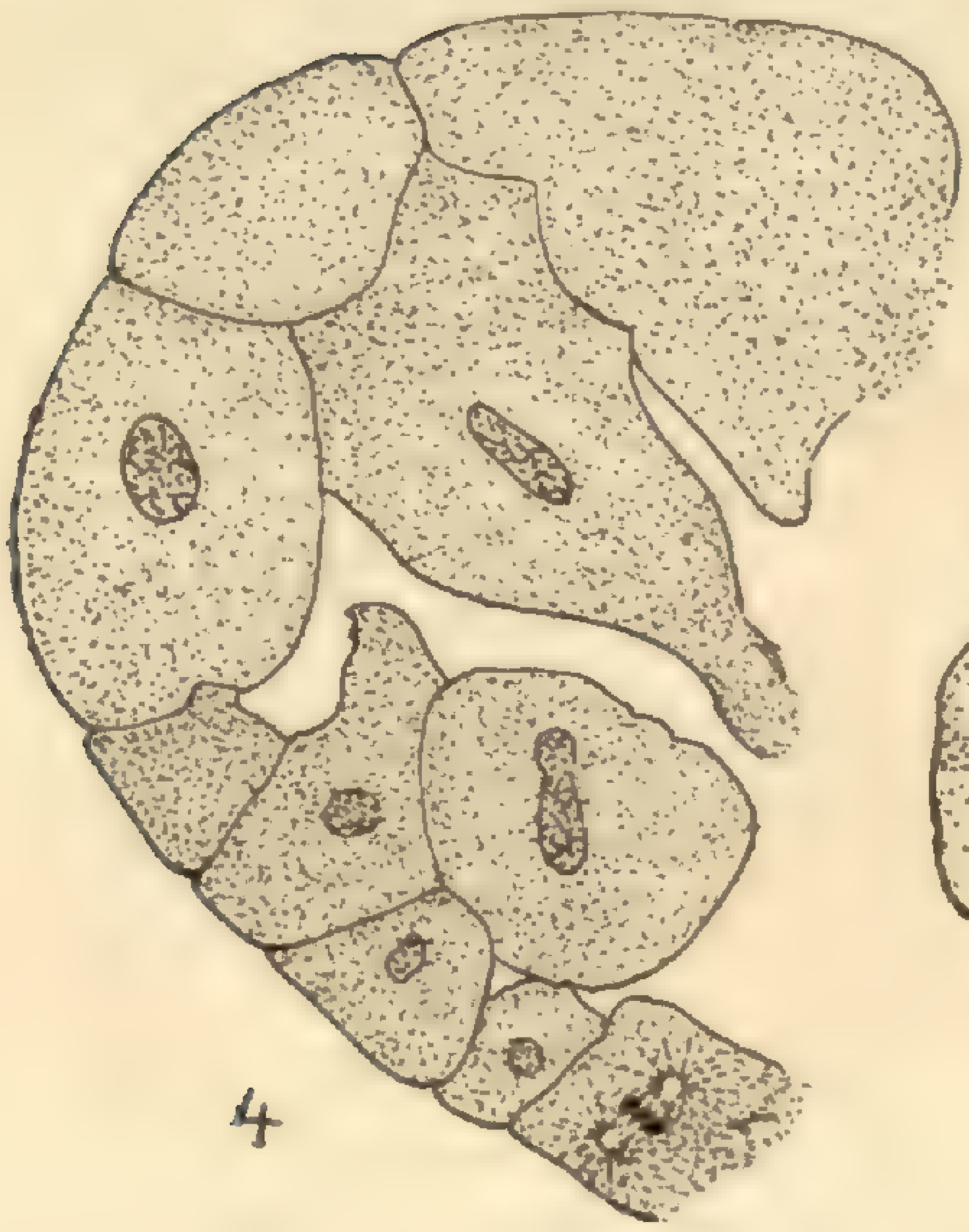

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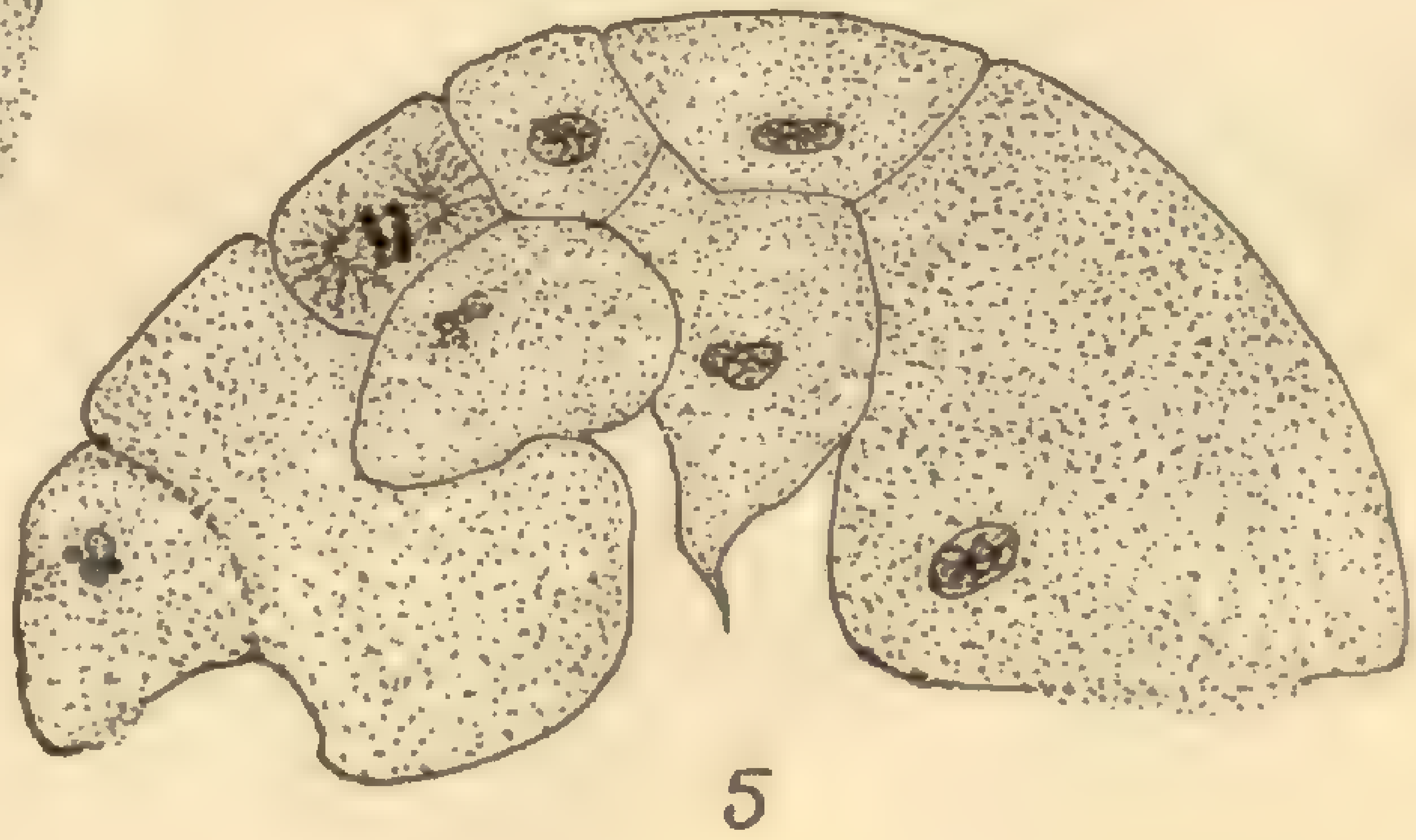

5

THE ORNITHOLOGICAL RESULTS OF THE POLAR EXPEDITION UNDER DR. NANSEN.

(A REVIEW.)

R. W. SHUFELDT.

WHAT was accomplished for the science of ornithology during the journey of the *Fram* under Dr. Nansen and the intrepid explorers and naturalists who accompanied him in the North-European polar seas, during the years 1893–96, now appears in the form of a valuable quarto brochure, issued by its distinguished authors, to whom my thanks are due for a complimentary copy.[1]

This excellent work exhibits throughout great care in preparation, scientific accuracy, and a marked attention to details, descriptions and methods of presentation of the facts in the hands of its authors. It is handsomely printed and is illustrated by two plates devoted to Rosse's gull (*Rhodostethia rosea*). The first of these is an uncolored one, facing page 16, and represents two specimens of the bird, suspended by their legs in such a manner as to exhibit the pattern of the plumage upon their ventral and dorsal aspects. They were shot August 3, 1894. In the second plate, at the close of the work, we have a beautiful colored figure of this famous gull sitting on the ice, with another individual in flight in the background. In the distance we see the *Fram* firmly frozen in the ice pack, while far beyond the horizon the picture is completed by the cold red sky of those north polar seas. The birds in this plate are specimens of the young in first plumage.

By the aid of my camera I have copied this latter plate and offer it here as an illustration to the present review.

[1] *The Norwegian North Polar Expedition, 1893–96.* Scientific Results edited by Fridtjof Nansen. — IV. An Account of the Birds by Robert Collett and Fridtjof Nansen. Published by the Fridtjof Nansen Fund for the Advancement of Science. Christiania, Jacob Dybwad; London, New York, Bombay, Longmans, Green & Co.; Leipzig, F. A. Brockhaus, 1899. Cloth, pp. 1–54, 1 plate, 1 figure in text.

From the Introduction we ascertain that the work is divided into four (IV) sections. In the first three sections the observations recorded are extracted from Dr. Nansen's personal journals, and supplemented by his verbal comments and explanations during the preparation of the work. The first section (I) has to do with the journey along the north coast of Siberia, from Yugor Strait (July 29, 1893), until the closing-in of the ship to the northwest of the New Siberian Islands on Sept. 25, 1893 (78° 50′ N. Lat., 132° 20′ E. Long.).

Rosse's gull (*R. rosea*). Young in first plumage. From a photograph of original plate by the author.

"The birds observed during this time were principally on their way southwards. After the closing-in of the ship, no birds were seen until the following year."

The second section (II) gives the observations made at the time that the *Fram* was drifting with the ice towards the northwest, during the first summer, 1894, up to the time when Nansen and Johansen started on their sledge journey, March 14, 1895. This last point lies in about 84° N. Lat., 101° 55′ E. Long.

"The first bird seen in the spring of 1894 (a gull, probably *Pagophila eburnea*) appeared on May 13; birds were seen now and again until after the middle of August. After August 23, or the day when all the channels and lanes about the ship began to freeze up, no birds were seen."

Eight specimens of *R. rosea* were shot and preserved during this part of the journey. They were all young birds of the year.

The third section (III) gives the observations made during the aforesaid sledge journey, in the spring of 1895 to August 1896. During the journey in the Polar Sea, the first bird seen (a *Fulmarus glacialis*) was observed on May 29, when the travelers had begun to approach the north side of Franz Josef Land. That part of the journey in which the highest latitude, 86° 13.6′, was reached was undertaken so early in the year that "no birds were yet visible."

The fourth section (IV) gives the observations made on the *Fram* after Nansen and Johansen had left in March, 1895, until the return of the ship in August, 1896. Great importance attaches to the ornithological records made during this part of the exploration. In the first place, "birds were observed in the highest northerly latitudes, in which birds on the whole have been known to exist," and farthest north of all was found *F. glacialis*, of which a specimen was observed in 85° 5′ N. Lat.

During this part of the cruise, the *Fram* being confined to a comparatively limited area northeast of Franz Josef Land, the total number of species observed was ten (10), namely, *Plectrophenax nivalis*, *Sterna macrura*, *Pagophila eburnea*, *Rissa tridactyla*, *Rhodostethia rosea*, a specimen of a Larus, which is stated to have been black-backed, a Stercorarius (species undetermined), *Fulmarus glacialis*, *Cepphus mandti*, and *Alle alle*. "None of the species, however, seemed to occur in any great quantity."

"The last summer, 1896, when the *Fram* was north of Spitzbergen, the first bird (a snow bunting) was observed on April 25. It now appeared that for a distance of at least four hundred kilometers north of Spitzbergen, or between 81° and 83° N. Lat., the Arctic Ocean is inhabited by an abundant bird life, doubtless consisting principally of young, not yet mature birds, which spend the summer months here, in and near the open channels in the ice." "Among the specimens occurring here, sometimes in great numbers, may be named *Cepphus mandti*, *Alle alle*, and *Pagophila eburnea*. A few specimens of waders (*Ægialitis hiaticula* and *Crymophilus fulicarius*) were also found in these northern latitudes, and a specimen of *Xema sabini* was observed."

Under the names of the various birds observed in the body of this memoir are given full accounts of habits, localities, plumage descriptions, and matters of general interest to ornithologists everywhere. At the close of the work we find an index, which simply presents the scientific names of the thirty-three (33) species of birds observed during the entire journey. They are as follows: *Ægialitis hiaticula*, *Alle alle*, *Anser segetum*, *Archibuteo lagopus*, *Arquatella maritima*, *Branta bernicla*, *Cepphus mandti*, *Colymbus arcticus*, *Crymophilus fulicarius*, *Falco æsalon*, *Fratercula a. glacialis*, *Fulmaris glacialis*, *Harelda glacialis*, *Lagopus lagopus*, *Larus argentatus*, *L. fuscus*, *L. glaucus*, *L. marinus*, *Nyctea scandiaca*, *Pagophila eburnea*, *Phalaropus hyperboreus*, *Plectrophenax nivalis*, *Rhodostethia rosea*, *Rissa tridactyla*, *Somateria mollissima*, *Squatarola helvetica*, *Stercorarius crepidatus*, *S. longicaudus*, *S. pomatorhinus*, *Sterna macrura*, *Totanus nebularius*, *Uria lomvia*, and *Xema sabini*. In other words, it will be noted that there was but one passerine bird observed (the snowflake, *P. nivalis*); a ptarmigan, five waders, two hawks and an owl, two ducks and two species of geese; and the balance of the list, made up of gulls, terns, guillemots, auks, fulmars, jægers, and the dovekie, together with divers and puffins, represent strictly a circumpolar avifauna — few birds, and those essentially boreal forms. Taken as a whole, this is one of the most important contributions to the ornithology of high northern latitudes now extant, and it constitutes a very substantial addition to our knowledge of the habits, species and migrations, plumages and variations of the ornis of the Arctic Circle, and its distinguished authors are to be congratulated upon the completion of their worthy labors.

SYNOPSES OF NORTH-AMERICAN INVERTEBRATES.

IX. The Scorpions, Solpugids, and Pedipalpi.

NATHAN BANKS.

THESE three groups belong to that order of the Arachnida known as the Arthrogastra. It may be separated from the other arachnids of the United States, and practically of the whole world, in the following manner:

Abdomen plainly segmented, palpi of male not modified for a genital organ, rarely of small size, no jointed abdominal spinnerets *Arthrogastra*
Abdomen not plainly segmented, joined to the cephalothorax by a slender pedicel, palpi of male modified for a genital organ, at least one pair of jointed abdominal spinnerets . . . . *Araneida*
Abdomen not plainly segmented, broadly united to cephalothorax, no jointed spinnerets, male palpi not modified, of small or even minute size *Acarina*

The three groups of the Arthrogastra treated in this paper are easily distinguished by the following characters:

1. Abdomen ending in a poison sting, base of abdomen beneath bearing a pair of appendages with teeth (pectines); palpi chelate at tips, legs without patellæ; posterior part of abdomen much narrower than the anterior part . . . . *Scorpionida*
   Abdomen not ending in poison sting; no pectines, palpi not chelate at tips 2
2. Hind coxæ bearing a few *T*-shaped appendages, hind trochanters of two segments, no sternum, no patellæ in any legs . . . . *Solpugida*
   Hind coxæ without such appendages, hind trochanters not bisegmented, patellæ in at least some of the legs; sternum often present, body considerably constricted between cephalothorax and abdomen *Pedipalpi*

PEDIPALPI.[1]

The Pedipalpi are tropical animals, so that there is but a

[1] The *American Naturalist* will undertake to determine and return any specimen that cannot be placed in the keys, and solicits corrections and criticism for future revision.

slender representation of them within our limits. These, however, belong to the three principal groups — Tartaridæ, Phrynidæ, and Thelyphonidæ. They are all of moderate to large size; there is a patella in at least some of the legs; there are no tactile organs on the hind coxæ; the mandibles are of moderate size; the body never ends in a sting; and the palpi are never chelate at the end; the abdomen is usually elongate, and when short it is not joined broadly to the cephalothorax, as in the Phalangida.

In the Tartaridæ the thoracic segments bearing the third and fourth pairs of legs are not united to the head, as in most arachnids, but free, and their scutæ showing as separate pieces on the dorsum. The abdomen is rather slender, tapering each way, and at tip is a long triangular telson. The palpi are short and terminate in a stout claw. The legs, except the first pair, are provided with a patella. The Thelyphonidæ are readily known by the presence of a long multiarticulate telson or tail; whence the popular name of "whip scorpions." The body is depressed and the abdomen joined broadly to the cephalothorax. Our single species, although greatly feared, is not poisonous.

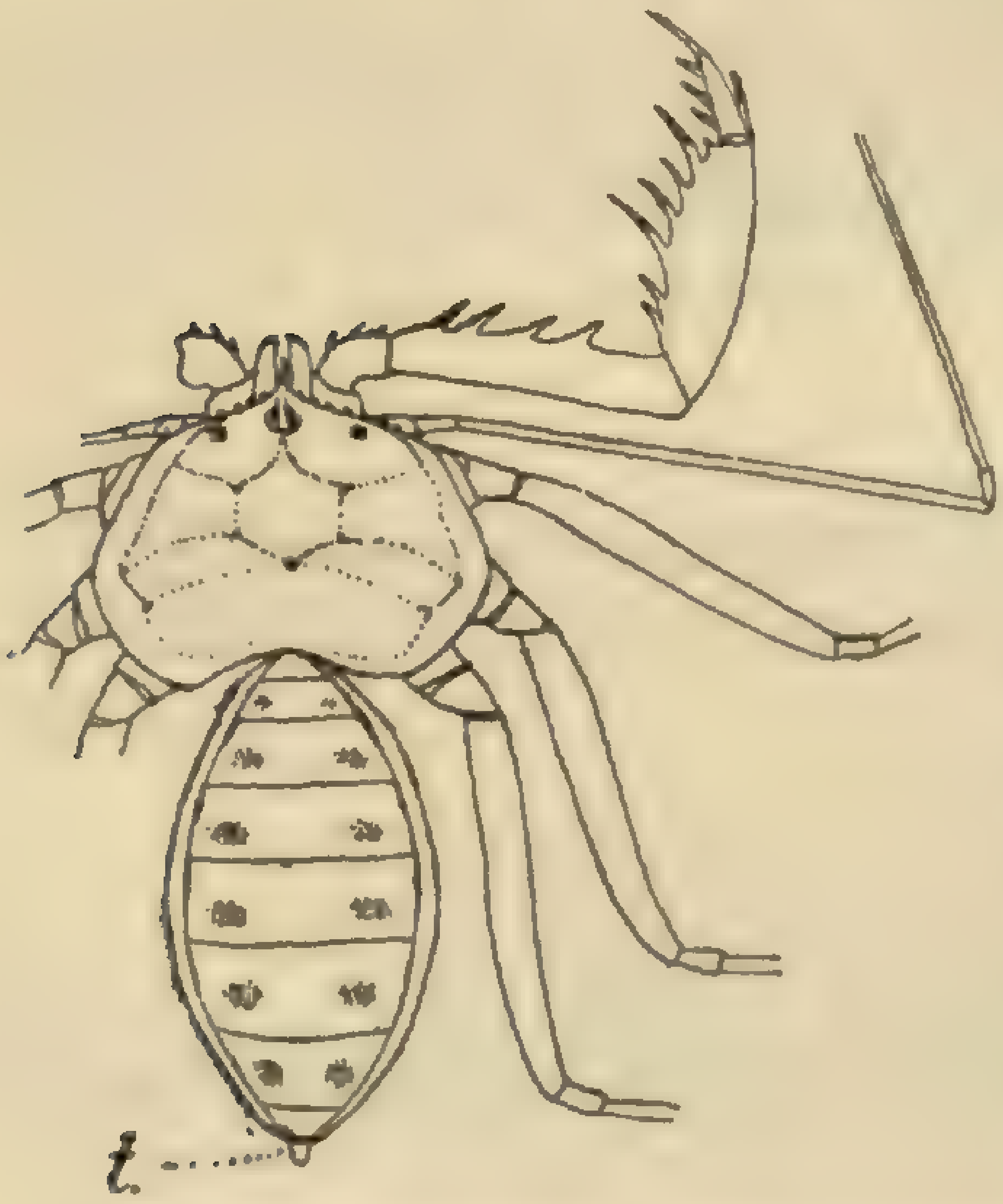

FIG. 1. — Admetus. *t*, telson.

The Phrynidæ are separable from the other Pedipalpi by the tenuity of the connection between the cephalothorax and abdomen. The body is broad and flat, without a tail. Of the three species recorded from our country, two are quite doubtful.

The Pedipalpi are tabulated as follows:

1. Cephalothorax transversely divided in posterior part, no eyes, telson short . . (fam. *Tartaridæ*) *Trithyreus pentapeltis* Cook (Cal.)
   Cephalothorax entire, eyes present 2
2. Abdomen with a long multiarticulate telson, abdomen quite broadly united to cephalothorax . . . . (fam. *Thelyphonidæ*) *Mastigoproctus giganteus* Lucas (Tex., Fla., Ariz.)
   Abdomen lacking long telson, joined to cephalothorax by slender pedicel . . . . (fam. *Phrynidæ*) 3

3. Frontal border of cephalothorax with long teeth, only two long spines on upper inner edge of tibia of palpus
Acanthophrynus coronatus Butl. (Cal.)
Frontal border of cephalothorax only denticulate, more than two long spines on upper inner edge of tibia of palpus, smaller species 4
4. Between the two longest spines of tibia of palpus there are two small spines . . . . *Admetus fuscimanus* Koch (Fla.)
Between the two longest spines of tibia of palpus is only one short spine
Admetus whitei Gerv. (Tex.)

Scorpionida.

The scorpions are readily known from all other arachnids by the presence of two peculiar characters; the body terminates in a poison sting, and on the venter, near base of abdomen, is a pair of appendages, each bearing a number of lamellæ; these are the pectines, or combs. The palpi are enlarged at tip and chelate; the claw being of three parts, *viz.*, the hand, or basal portion, and two fingers, one movable, the other fixed. There are usually three groups of eyes. The last five segments of the body are much narrower than the others and form the cauda or tail. These segments bear ridges which are called "keels." The legs have no pa-

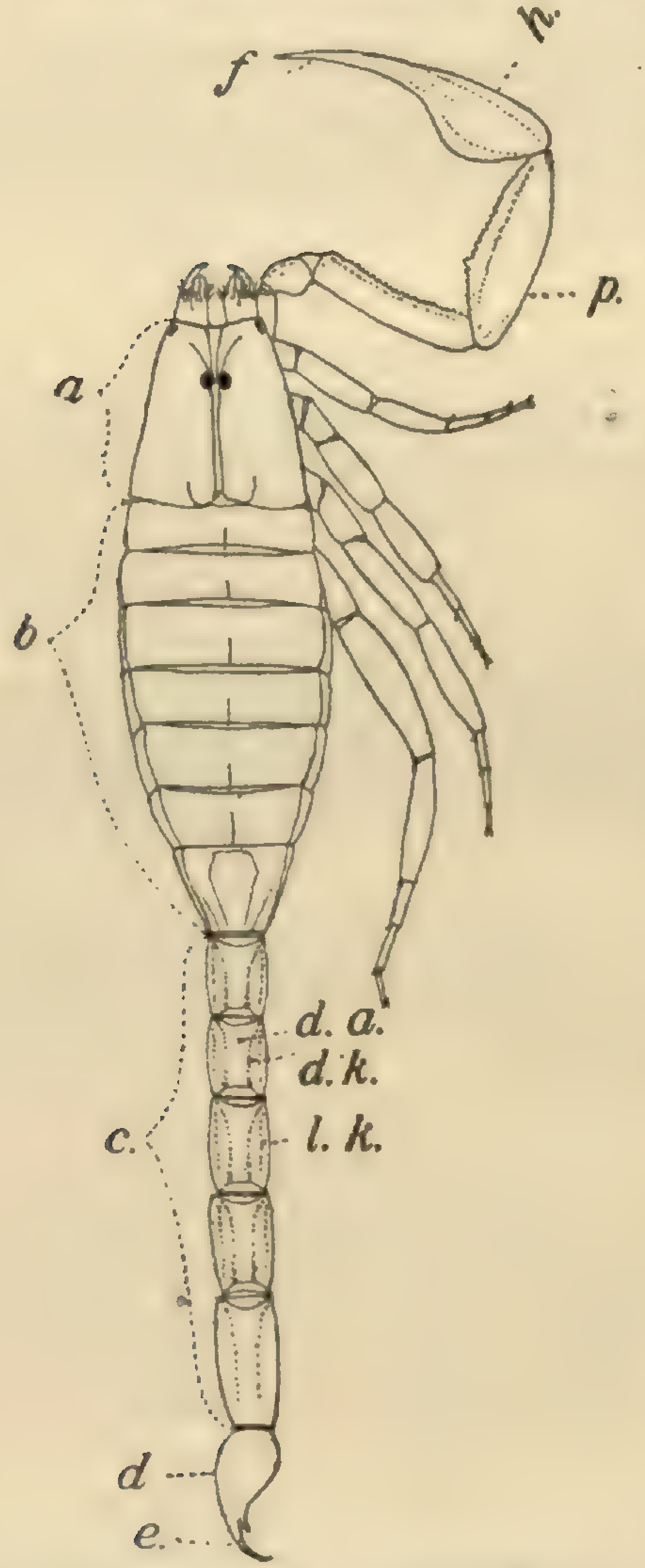

Fig. 2.—Centrurus. *a*, cephalothorax; *b*, abdomen; *c*, cauda; *d*, telson; *e*, sting; *p*, palpus; *h*, hand; *f*, fingers; *d.a.*, dorsal area; *d.k.*, dorsal keel; *l.k.*, lateral keel.

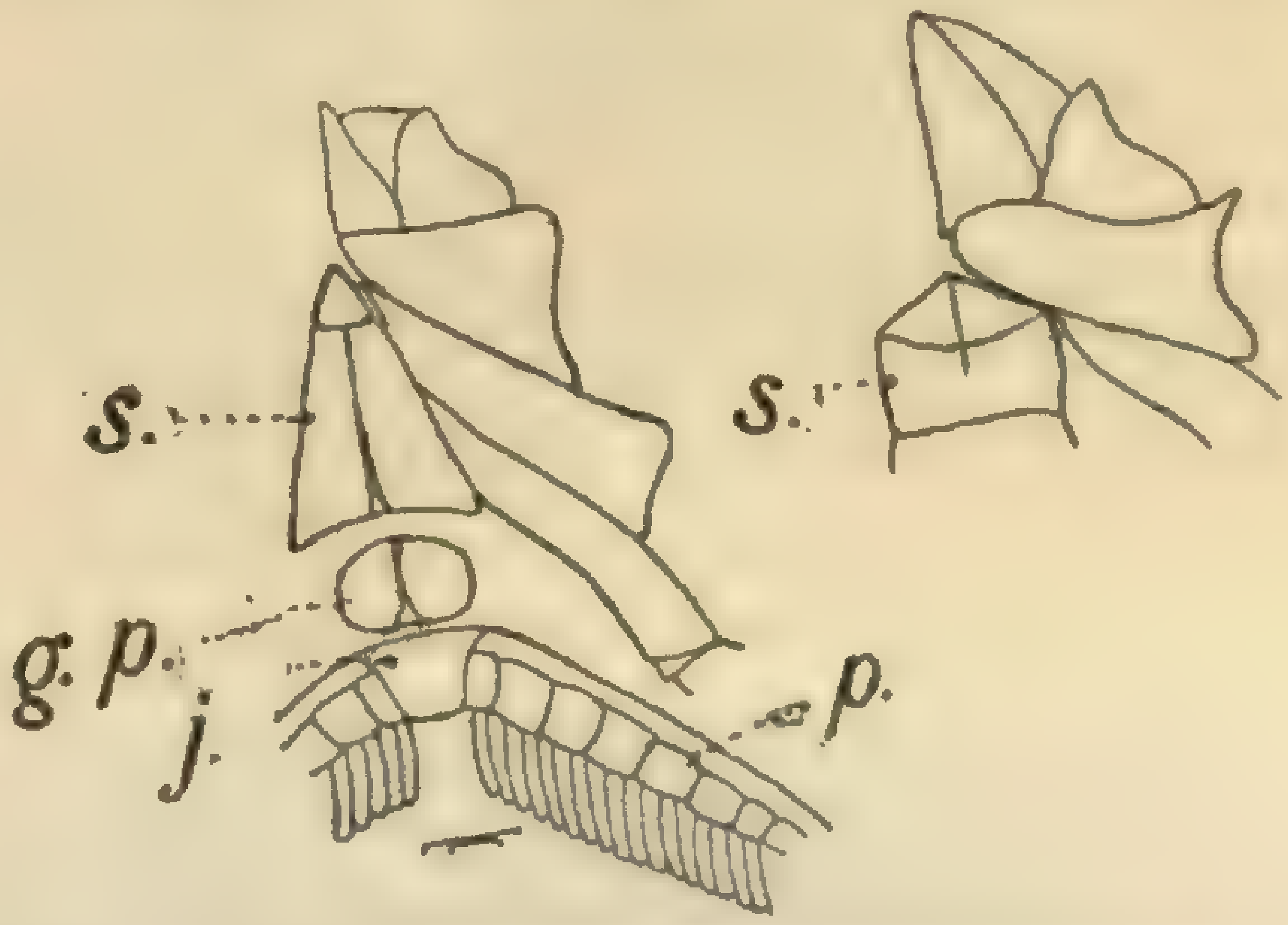

Fig. 3.—The two forms of sterna in scorpions. *s*, sternum; *g.p.*, genital plate; *j*, jugum.

tella. The exact number of species occurring in our country is uncertain, owing to the fact that several Mexican species may be found in southern Texas.

1. Only two lateral eyes; sternum broad, pentagonal; small short species (fam. *Chactidæ*) *Broteas alleni* Wood. (S. Cal.)
Three to five lateral eyes 2
2. Sternum broad, pentagonal, usually no spine under the sting . . 3
Sternum long, triangular, usually a spine under the sting . . . 14
3. At base of last tarsal joint at least one spur on inner and one on outer side; no spine under the sting . . . . (fam. *Vejoviidæ*) 6
At base of last tarsal joint only one spur, which is on the outer side; sometimes a hump under the sting . . . (fam. *Scorpionidæ*) 4
4. A hump under the sting 5
No hump under sting; cephalothorax deeply emarginate on anterior margin, cauda small, claws large, color dark
Opisthacanthus elatus Gerv. (S. Fla.)
5. Comb with six to eight teeth . . *Diplocentrus lesueuri* Gerv. (Fla.)
Comb with twelve to fifteen teeth
Diplocentrus whitei Gerv. (Tex., Cal.)
6. Central area of each comb divided into at least eight small pieces 8
Central area of each comb divided at most into six small pieces 7
7. Movable finger with at least five small teeth, sting of ♂ as usual
Uroctonus mordax Th. (West Coast)
Movable finger with at most three small teeth, sting of ♂ swollen at base . . . . . *Uroctonus phaiodactylus* Wood. (Cal., Utah)
8. Penultimate tarsal joint of three front legs with long hairs on back; a strong tooth near the under edge of the movable mandibular finger; very large and hairy
Hadrurus hirsutus Wood. (Southwest)
No hairs on back of these tarsal joints, no tooth near tip of under edge of movable mandibular finger, smaller species . . . (*Vejovis*) 9
9. Hand with distinct ridges or keels, more or less granulate . . 10
Hand smaller, without keels, the corners rounded and smooth . 12
10. On the underside of the first caudal segment the median keels are distinct and sharp, although fine, the sting is very slender and long
Vejovis punctipalpi Wood. (N. Mex., Nev.)
On the underside of the first caudal segment there are no median keels or extremely indistinct, the sting of ordinary length 11
11. Hand strongly keeled, no keels on hind tibiæ, color yellowish or greenish . . . *Vejovis boreus* Gir. (Neb. to Idaho, Utah, and Nev.)
Hand less sharply keeled, hind tibiæ with very plain keels, color uniform reddish-brown, legs paler . *Vejovis mexicanus* Koch (Tex.)
12. On under side of first caudal segment the median keels are plain, but

not indicated by black lines, hand very slender, the fingers longer than in *Vejovis spinigerus*, color uniform yellowish
Vejovis flavus Bks. (N. Mex.)

On underside of first caudal segment no median keels, or at most only indicated by black lines 13

13. Underside of cauda not very dark, the keels all indicated by black lines, palpi usually yellowish
Vejovis spinigerus Wood. (Tex., Ariz., Cal.)

Underside of cauda, with the whole of dorsum and the palpi dark reddish-brown ; no black lines indicating the keels on cauda, smaller than the preceding . . . *Vejovis carolinus* Koch (S. C. to Tex.)

14. A tarsal spur at end of the first tarsal joints of legs 3 and 4
(fam. *Buthidæ*)

Pale ; no spine under sting, teeth on finger of palpus in many oblique rows, with stouter teeth at end of each and to one side ; thirty to thirty-five teeth in combs, under keels of last caudal segment very strongly toothed . . . *Uroplectes mexicanus* Bks. (Tex., Cal.)

No tarsal spur at apex of first tarsal joints, usually a spine under the sting . . . . (fam. *Centruridæ*) 15

15. The oblique rows of teeth on the finger of palpus have on each side a parallel row of minute teeth . . . . (*Centrurus*) 17

No parallel rows each side 16

16. The ends of the oblique rows of teeth overlapping, a distinct spine under sting, twenty to twenty-two teeth in comb, color dark red brown . . . . *Tityus floridanus* Bks. (S. Fla.)

The ends of the rows not overlapping but often connected in one direct line, cauda and palpi very long and slender
Isometrus maculatus De Geer (S. Fla.)

17. No spine under the sting, cauda very long and slender
Centrurus exilicauda Wood. (Cal.)

At least a small spine or tubercle under the sting, cauda less slender 18

18. Body vittate with black and yellow 22

Body nearly uniform reddish-brown or blackish 19

19. Body a dark greenish-black, cephalothorax very rough, cauda strongly granulate . . . . *Centrurus nigrescens* Pock (Tex.)

Body reddish or yellowish brown 20

20. Fingers paler than hand, yellowish, otherwise dark red brown, spine under sting often small and blunt *Centrurus margaritatus* Gerv. (Fla.)

Fingers usually darker than hand 21

21. Color yellowish-brown, combs with rarely more than twenty-four teeth, spine under sting not very prominent
Centrurus testaceus De Geer (S. Fla.)

Color reddish-brown, combs with usually more than twenty-five teeth, spine under sting well developed, usually much larger than the preceding . . . . *Centrurus gracilis* Gerv. (Fla.)

22. A small pale median spot on the anterior border of the cephalothorax, legs pale yellow, cauda pale

Centrurus carolinianus Beauv. (S. States)

No such median spot on anterior margin of the cephalothorax, legs marmorate with brown, cauda brown, dark stripes on cephalothorax, broader than in preceding . . . *Centrurus hentzi* Bks. (Fla.)

Solpugida.

These curious arachnids are strongly separated from all other groups by various characters. There is a pair of thoracic stigmata; the cephalothorax is divided into three parts, the posterior two not covered with a chitinous shield; the mandibles

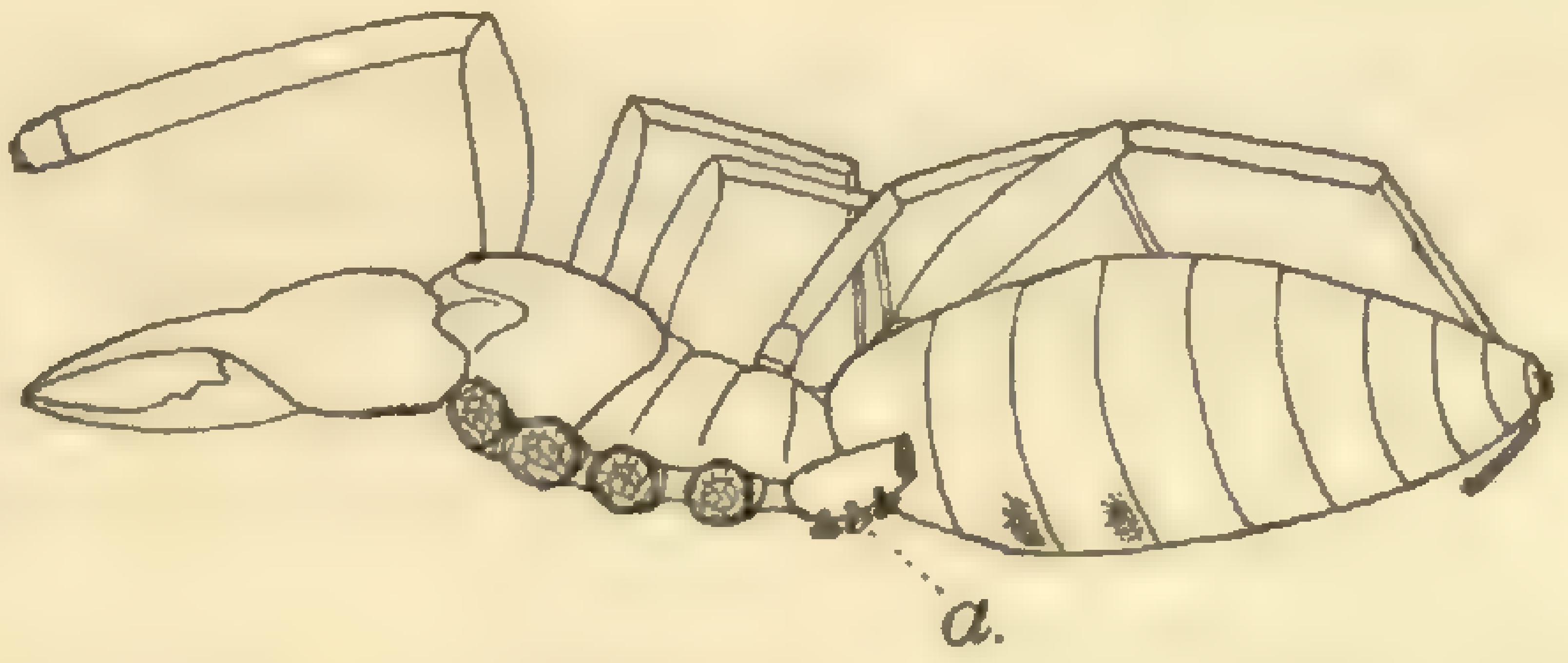

Fig. 4.— Eremobates. *a*, coxal appendages.

are very large and porrect; the hind coxæ bear several *T*-shaped appendages; the hind trochanters are bisegmented; the coxæ are approximate, so that there is no sternum. The body is not depressed in the slightest—a rare character in the other Arthrogastra (except Phalangida).

The species live in wild desert, often sandy, regions, and wander chiefly at night. Our genera and species may be tabulated as below.

1. Anterior margin of the cephalothorax rounded, sloping each side

(*Ammotrecha*) 9 [1]

Anterior margin truncate . . . . (*Eremobates*) 2 [2]

2. Movable finger of ♂ mandibles with two large subequal teeth with denticles between them 3

Movable finger with but one large tooth, others much smaller . 4

3. Some short conical spines under tibia of the palpus in both sexes

Eremobates sulphurea Sim. (Colo., N. Mex.)

No such spines under tibia in either sex

Eremobates formicaria Koch (N. Mex.)

[1] Ammotrecha, *n.n.* for Cleobis Simon (1879), not Dana (1847).

[2] Eremobates, *n.n.* for Datames Simon (1879), not Stal (1875).

4. Movable finger of ♂ mandibles constricted from below near apical third
Eremobates californica Sim (Ariz., Cal.)
Movable finger not constricted from below 5
5. The movable finger near apical fourth is suddenly narrowed from above, very large species . . . . . *Eremobates cinerea* Putn. (Ariz.)
The movable finger, if narrowed from above, it is much before the apical fourth 6
6. Only slender hairs on inner side of femur and tibia of ♂ palpus
Eremobates pallipes Say (Kan., Tex., Colo., Wy.)
Spine-like bristles on inner side of femur and tibia of ♂ palpus 7
7. Upper finger stouter than usual, narrowed near tip, a small tooth near middle of movable finger, tips of palpi black
Eremobates magna Hanc. (Tex., Ariz.)
Upper finger slender throughout, no tooth near middle of movable finger 8
8. Small conical spines on underside of tibia of ♂ palpus
Eremobates formidabilis Sim. (Cal., Ariz.)
No such spines on tibia of ♂ palpus
Eremobates putnami Bks. (Cal.)
9. Lower finger of mandibles finely, but distinctly, denticulate beyond large teeth ; a broad dark band on middle of metatarsus of palpus
Ammotrecha californica Bks. (Cal.)
Lower finger not denticulate 10
10. Upper finger with a very plain ridge above at base, below there are several small teeth followed by three large subequal teeth
Ammotrecha peninsulana Bks. (Ariz.)
Upper finger with less distinct ridge, below there are two large teeth, a small one, then a large one . . *Ammotrecha cubæ* Lucas (Fla.)

REVIEWS OF RECENT LITERATURE.

ANTHROPOLOGY.

The Natural History of the Musical Bow. — Mr. Henry Balfour, the distinguished curator of the Pitt-Rivers Museum at Oxford, has recently published a monograph of eighty-seven pages, with many illustrations, upon the Musical Bow. The archer's bow is regarded as the prototype of a large series of stringed instruments of music. Though some writers consider the bow as the origin of all stringed instruments, Balfour believes that we must refer back to a plurality of ancestors for this class of instruments. Three stages are observable in the transition from the archer's bow, pure and simple, to the bow adapted specially for the production of musical sounds.

1. The archer's bow is temporarily converted into a musical instrument at the present day by the tribes of southwest Africa — the Damaras, Mandingos, Kaffirs, etc.

2. The second stage is represented by those monochord instruments that are practically bows and nothing more, but which are made for musical purposes alone. These are found in the Niger and Benue river regions, in the Kamerun, Lower Guinea, and Fernando Po countries.

3. The third stage is that in which a resonator is attached more or less permanently to the bow. To this class belong a large number of African instruments covering a wide area, chiefly south of the equator, and principally associated with people of the widespread Bantu stock.

Mr. Balfour is "convinced that nothing of the nature of a musical bow is represented" by the figure in the Mexican codex, which Mr. Saville identified as a musical instrument used by the ancient Mexicans. The author believes that the custom of using the musical bow in America was introduced from Africa. The accompanying map shows that the instrument is used in Patagonia, Bahia, Surinam, Central America, Mexico, and the West Indies in the New World. It is not found outside of India and Japan in Asia. In Europe the bow has been the legendary prototype of musical instruments in Greece and Rome. It is not found in Australia.

F. R.

Report of the United States National Museum, 1897. — In a monograph of 282 pages Mr. Joseph D. McGuire describes "American aboriginal pipes and smoking customs." Two hundred and thirty-nine figures in the text and four plates illustrate the various types of pipes and their distribution over the American continent.

The custom of smoking prevailed in the New World for centuries before the arrival of the whites. The pipes used were of an endless variety of substances, shaped in as many forms as there were materials. The straight tube was the most primitive form and was the only one common to the whole continent. Mr. McGuire's conclusions are too extended for presentation in a brief review, yet it is worthy of note that he regards many types as modern — produced subsequent to the time of the discovery. For example, "The disk pipe, usually found in the states of Illinois, Missouri, and Kentucky, with specimens from Ontario, are of mound type, though their outline is so similar to the jew's-harp as to raise suspicion that such an instrument furnished the model for the pipe." "The Iroquoian pipes found along the river St. Lawrence and in the neighborhood of the Great Lakes may be said to vary one from the other more than pipes found in the eastern United States. . . . These pipes with but slight doubt show that their period is subsequent to the arrival of the French." "The form called the Delaware pipe appears to be of totemic character, is carved with considerable skill, and impresses one as being of recent origin, and made with modern metal tools." Even the skillfully shaped mound pipes are believed to have been made with metal tools obtained from the early French traders and voyageurs.

"Te Pito Te Henua, known as Rapa Nui: commonly called Easter Island, South Pacific Ocean," is the title of a belated article by Geo. H. Cooke, surgeon, U. S. N. The island lies 2.100 west of the South American coast and 1.100 east of Pitcairn Island, the nearest inhabited land. In 1886 the population had been reduced from several thousand to 155 natives. The mental and physical characters of the people are described, a vocabulary of three pages is furnished, and some account is given of their villages and habitations. The remarkable ruins of the island were reported upon by W. J. Thomson, U. S. N., in the *U. S. National Museum Report for 1889*. Dr. Cooke alludes to the belief among the present inhabitants that their own ancestors carved the megalithic monuments.

"The Man's Knife among the North American Indians — a study in the collections of the U. S. National Museum" — is a paper of eighteen pages by Professor O. T. Mason, and supplements that published in 1890 upon "The Ulu, or Woman's Knife." The knives used by the men of the American race may be classified in three groups: the curved knife, straight blade, and a metal blade performing the function of a burin. With the introduction of iron the arts of the peoples using the curved knife were greatly improved. This is especially noticeable in the Northwest, where the carving of the older period with beaver-tooth or shark-tooth knives was of an inferior kind.

"Arrow Points, Spearheads, and Knives of Prehistoric Times," a profusely illustrated paper of 188 pages, by Dr. Thomas Wilson, concludes the volume. After dealing with the spears and harpoons of the paleolithic period, the origin, invention, and evolution of the bow and arrow, and superstitions concerning arrow points and other prehistoric stones in the opening chapters, Dr. Wilson describes the flint mines and quarries in western Europe and in the United States. From the quarry at Spiennes, Belgium, flint implements have been distributed over southern Belgium and northeastern France. Fifteen neolithic stations, extending over forty-five communes, have been found, all in direct relation with Spiennes, creating a network of roads which have remained in use until modern times.

At Grand Pressigny the débris of the flint quarries still encumbers the ground for miles around. It is of a peculiar yellow or waxen color, and hence can be easily traced through northern, western, and central France, and even into some of the lake dwellings of Switzerland. At Mur-de-Barrez, France, shafts and galleries were dug in the search for the best flint. Perhaps the best known quarry is that at Brandon, England, which covers twenty acres and consists of shafts or pits partly filled, dispersed over the surface, sometimes so close together as to break into one another.

The best known flint quarry in the United States is at Flint Ridge, Licking County, Ohio. The ridge is about eight miles in length east and west, and two and one-half north and south. The flint is not in nodules, but in a continuous stratum from three or four to seven feet thick. The worked area is about two miles square and is covered with soil to a depth of four to ten feet.

The composition and structure of the materials employed in the manufacture of arrow points and spearheads are illustrated in repro-

ductions from microscopic sections. These weapons are then classified in several groups, according to their shape. Dr. Wilson believes many of the "humpbacks" were not rejects, as has been supposed, but that they were intentionally chipped into this form to be used as knives. Again, many of the implements having the form of arrow and spear points were intended to be used as knives.

F. R.

The Report of the Commissioner of Education for 1897–98 contains a vast amount of information relating to educational interests in America and in foreign countries. A chapter is devoted to education in Cuba, Porto Rico, and the Philippines. Besides the education of the older civilized countries, that of Australia, Tasmania, and New Zealand, of India and various South American republics, is considered. Of special interest to anthropologists is the chapter upon psycho-physical and anthropometrical instruments of precision in the laboratory of the Bureau of Education. Many of the ninety-two illustrations represent new pieces of apparatus. Dr. Arthur MacDonald contributes an exhaustive experimental study of Washington school children (pp. 989–1140). The investigation included a special study of 1.074 children and the anthropometrical measurement of 16.473 white and 5.457 colored children. His conclusions as to the children specially studied were :

1. "Dolichocephaly, or long-headedness, increases in children as ability decreases. A high percentage of dolichocephaly seems to be a concomitant of mental dullness.

2. Children are more sensitive to locality and heat on the skin before puberty than after.

3. Boys are less sensitive to locality and more sensitive to heat than girls.

4. Children of the non-laboring classes are more sensitive to locality and heat than children of the laboring classes.

5. Colored children are much more sensitive to heat than white children. This probably means that their power of discrimination is much better, and not that they suffer more from heat."

In Dr. MacDonald's conclusions from study of the larger series of children we find the surprising statement that "in colored children brightness increases with age — the reverse of what is true in white children."

An educational directory concludes Part I of Vol. I. F. R.

Notes. — The Smithsonian Institution has issued a reprint, in a single pamphlet, of two papers by Professor Otis T. Mason that were published in the *Smithsonian Reports* for 1876 and 1884: "The Latimer Collection of Antiquities from Porto Rico in the National Museum," and "The Guesde Collection of Antiquities in Point-à-Pitre, Guadeloupe, West Indies."

In his preface to the reprint Professor Mason states that considerable literature has accumulated relating to the Greater and Lesser Antilles since the first publication of the papers. The number of collars known now amounts to one hundred, the number of zemes has been also greatly increased. The Guesde collection is easily identified with the Carib work of the continent of South America. The preface concludes with a list of publications relating to West Indian antiquities which contains thirteen titles.

In the *Proceedings of the Linnæan Societies of New South Wales* Mr. R. Etheridge, curator of the Australian Museum, describes the spear becket of New Caledonia. The beckets in the Australian Museum are from six to thirteen inches long and are of plaited cord, with an "eye" at one end and an "overhand" knot, or a "grummet head," at the other. The cord is a square or flat sinnet made from tightly twisted rush or grass, or a less tightly twisted beaten-bark string. Labillardière is quoted as authority for the statement that the beckets of New Caledonians were of cocoanut fibre and fish skin at the beginning of this century. Twelve beckets are figured in the five accompanying plates.

Mr. Etheridge describes also the "widow's cap" worn during the period of mourning by Australian women. It is of gypsum plaster, two or three inches in thickness, and varying in weight from four to fourteen pounds.

Mr. W. R. Harper gives an account of the exploration of aboriginal rock shelters at Port Hacking, Australia. Human skeletons and objects made by man were found. Two of the three shelters mentioned contained impressions of hands in red and black pigment.

The *Annual Report* of the director of the Field Columbian Museum for 1898–99 contains a number of valuable plates, a half dozen of which are of anthropologic interest. The list of accessions to the department of anthropology includes several groups of figures illustrating aboriginal industries and customs.

Dr. Ales Hrdlička presented before the annual meeting of the American Medico-Psychological Association, 1899, the results of his

examination of the brain of an adult male Eskimo, a member of the party of six brought to New York in 1896 by Lieutenant Peary. In size and complexity of conformation the cerebrum indicated a degree of development equal to that of the average white person. The parts of the encephalon did not have the relative proportions that exist in the white brain. The frontal lobes were about equal in size to those of whites, while the portions posterior to the fissure of Rolando were considerably larger. The paper is illustrated by seven excellent plates.

In a reprint from the *Archives of Neurology and Psychopathology*, Vol. I, No. 4, 1898, we find a discussion by Dr. Hrdlička of the "Dimensions of the Normal Pituitary Fossa, or Sella Turcica, in the White and Negro Races, an anatomical study of fifty-seven normal skulls of white and sixteen normal skulls of colored individuals." Since marked enlargements of the pituitary body are of a pathogenic nature, it is considered desirable to determine the normal dimensions and the range of variation in its size. This can best be accomplished by measuring the pituitary fossa. The length, width, and depth of the fossa were measured, and a module derived similar to the skull module of Schmidt. The relation to the total size of the skull was obtained by multiplying this module by 1000 and dividing the result by the circumference of the skull, expressed in centimeters.

F. R.

GENERAL BIOLOGY.

Protoplasmic Streamings. — Martin Heidenhain[1] adds some very interesting observations to our knowledge of the remarkable phenomena of currents seen in so many vegetable cells. In the elongated cells of the hairs in the flowers of the pumpkin he studied especially the movements of the granules. In favorable specimens there are apparent gliding movements of the granules, even when the protoplasm seems quiet. Frequently, however, the protoplasm is actively moving in masses, producing those constant changes in the form and arrangement of the strands that join the central, nucleated region with the protoplasm lining the cell wall, that have been described by other observers. But even when there is, apparently, temporary rest of the protoplasm, the granules may move

[1] Einiges über die sogenannten Protoplasma-Strömungen, *Sitz.-Ber. Phys.-Med. Gesell. Wurzburg*, 1898.

along as if carried by a current; that they are not in a current of protoplasm seems demonstrated, the author thinks, by the fact that granules pass in different directions close to one another, and one may even advance against the "stream" or crowd of others going in an opposite direction. These same facts strengthen the author's belief that protoplasm is not a liquid.

The author explains these apparently automatic movements of the granules (and of the chlorophyll bodies) as due to contractility, not resident in the granule but in the adjacent protoplasm. He adopts the inotogmata hypothesis of Engelmann, and conceives fibrils made of living particles *temporarily* joined. Along those transitory fibrils waves of contraction proceed, and thus the adjacent, inert, dead granules are, in some way, forced along. The granules are moved along in temporary routes made by the contractile fibrils.

The basis for the assumption of such hypothetical fibrils is: (1) the existence of visible fibrils, (2) certain changes in optical value, and (3) waves of contraction seen under the microscope. The author agrees with Bütschli that the structure of the protoplasm in these cells is that of a foam; he sees striations and cross-connections in masses where shape and arrangement change in such wise that the existence of a foam seems to underlie the above appearances.

But in the structure lines, lamellæ he thinks them, he also sees long and short fibrils which are sometimes stationary, sometimes moving along like granules. These curious fibrils are soft and easily break up; they are, he maintains, in the walls of the alveoli, that is, between the vesicles of the foam structure. He supposes these fibrils are the remnants, or ruins, of hypothetical contractile lines of protoplasm which are no longer functional.

The changes in optical value spoken of are passages from bright to dark which are seen in the lamellæ, and interpreted as being coexistent with changes in the contractile material.

The waves of contraction seen are bendings in the usually straight lamellæ, or striations.

Whatever the nature of these remarkable interalveolar fibrils, their existence harmonizes the divergent views of Flemming and of Bütschli to the extent that a foam structure is found with actual fibrils between the alveoli; in this and in several other points the author's observations confirm some of the facts recorded for various animal cells by G. F. Andrews[1] and open a most suggestive field of research upon oft-tried material. E. A. A.

[1] *The Living Substance.* Boston, Ginn & Company, 1897.

ZOÖLOGY.

A New Practical Zoölogy.[1] — A new elementary text-book of practical zoölogy on the lines already made familiar by Huxley and Martin's *Elementary Biology* has been published under the joint authorship of the late T. J. Parker and W. N. Parker. The student finds an introduction to the principles of zoölogy through a study of the frog, which occupies somewhat more than a third of the volume. Then follow chapters on the amœba, hæmatococcus, infusorians, hydra, earthworm, crayfish, fresh-water mussel, amphioxus, dogfish, and rabbit. Many of these chapters include discussions of general zoölogical problems especially well illustrated by the particular animal under consideration; thus, under Infusoria, biogenesis and abiogenesis are discussed, and under Hydra and its allies, alternation of generations. The book is concluded with a chapter on the structure of the cell and its rôle in development, as illustrated by vertebrate embryology. There are numerous good illustrations, and the practical directions are such as are of real value. The volume forms an important contribution to the list of laboratory text-books. P.

Gogorza's List of the Vertebrate Animals of the Philippines. — In the *Annals of the Natural History Society of Madrid* for 1888, José Gogorza y González gives under the title of "Datos para la Fauna Filipina," a list of the vertebrate animals known from these islands. The list is based largely on the collections in the museum at Madrid, the collections of numerous Spanish engineers and explorers, notably Francisco Martinez, Carlos de Mazarredo, José Pérez Maeso, Domingo Sánchez, and Regino Garcia.

Thirty-five species of mammals are recorded: 156 of birds, 87 of reptiles, 10 of amphibians, and 292 of fishes. No new species are described in any group. The nomenclature of the fishes is not very modern, being apparently based solely on Günther's *Catalogue of the Fishes of the British Museum*. There is, however, evidence that the work has been conscientiously performed. All the species mentioned are ascribed to a definite locality, a fact which indicates that the paper is not at all a compilation, and that the collection on which it is based is a very rich one, though doubtless not including more than a third of the fishes actually visiting these islands. D. S. J.

[1] Parker, T. J., and Parker, W. N. *An Elementary Course of Practical Zoölogy.* xii + 608 pp., 156 illustrations. New York, The Macmillan Company, 1900.

Lungless Salamanders. — In the *Zoologischer Anzeiger*, Dr. Einar Lönnberg, of Upsala, has an interesting list of salamanders which have the lung rudimentary or wanting. The catalogue includes the results of his own work and that of Harris Wilder, Camerano, and Moore.

Salamanders may in this regard be divided into three classes: (1) those in which the lungs extend to the groin and are about 60 per cent of the length of the body. To this class belong certain Asiatic species of Diemictylus (Molge); (2) those in which the lungs extend only halfway from the axil to the groin, measuring 38–45 per cent of the length of the animal. To this class belong other species of Diemictylus, species of Salamandrella, Ranideus, and, among American species, *Ambystoma punctatum* and *A. microstomum.* Apparently the American species of Diemictylus (viridescens, torosus) have not been studied; (3) those without lungs or with merely a rudiment. In this class, among American species, belong the following: *Ambystoma opacum* (rudiment), *Aneideslug ubris*, *Plethodon cinercus*, *P. glutinosus*, *Spelerpes porphyriticus*, *S. ruber*, *S. longicauda*, *S. guttolineatus*, *S. bilineatus*, *Manculus quadridigitatus*, *Desmognathus fuscum*, *D. brimleyorum*, *D. nigrum*, and *D. achrophæum.* Other species of Spelerpes, with Leurognathus and Batrachoseps, are known to belong to this category, which probably includes all Plethodontidæ and Desmognathidæ.

"Camerano has rightly pointed out the importance of the lungs as a hydrostatic organ, and it seems quite possible that the great length of the lungs in many forms is an adaptation to aquatic life. But the lungless salamanders are not necessarily obliged to lead a terrestrial life, even if many of them do so; on the contrary, some of them are very positively aquatic in their habits." Such do not, however, as is the case with Diemictylus, remain suspended in the water, but crawl or wriggle at the bottom.

D. S. J.

The Egg of the Hagfish. — In the *Proceedings of the Natural History Society of Copenhagen*, Adolf Severin Jensen has a valuable account of the egg of the hagfish (*Myxine glutinosa*), entitled "Om Slimaalens Æg."

The egg of this singular creature was first described in 1859 by Allen Thompson. It has been noticed a few times since then, mostly from specimens taken in the stomachs of other fishes, but most who have written on the animal and its biology have never found a perfect egg.

The conclusion of Mr. Jensen's observations is that the hagfish fastens its egg by wiry, hair-like appendages to objects on the sea bottom. These appendages are fastened to either pole of the egg, which is oval in form. Jensen figures a dead stalk of Cellepora, to which four eggs are attached. He gives also several figures of the sucker-like anchors ("thread cells," or "spider cells"), each with two to four lobes in which the hairs which hold the egg terminate.

A species of hagfish (*Polistotrema stouti*), rather distantly related to Myxine, occurs on the Pacific coast, and is abundant in the Bay of Monterey, where various features of its structure have been studied by several workers in the Hopkins Seaside Laboratory, notably by Dr. G. C. Price, Dr. F. M. McFarland, Dr. C. W. Greene, Dr. Bashford Dean, Dr. Franz Döflein, and Dr. Howard Ayers. For a long time the egg of this species was unknown. At last the Chinese fishermen began to bring them in, saying that they got them by pressing the bodies of the females. Many of them were half decomposed when received. Later Dr. Dean and Dr. McFarland discovered that these eggs were not taken from the females at all, but from the stomachs of the males, which accounts for their half-digested condition. Nearly all the eggs of hagfish thus far found at Monterey are from the stomachs of male fishes.

Dr. Dean figures one individual in which the clumps of wiry filaments which hold the egg are caught in the encasing slime of an adult animal. The investigations of Mr. Jensen indicate that these eggs should be sought on the sea bottom attached to bryozoa or algæ.

Mr. Jensen notes that the Atlantic hagfish has no larval or Ammocœtes stage, such as the lamprey passes through, the young, of six centimeters, being similar to the grown fish. In this respect the California hagfish agrees with Myxine.

D. S. J.

Waite's Fishes of the Thetis Expedition. — In the *Memoirs of the Australian Museum*, Mr. Edgar R. Waite gives an account of the fishes taken by the trawling expedition of H. M. S. C. *Thetis*, Capt. C. P. Hildebrand, in the waters about Port Jackson. The collection obtained, of which a brief preliminary report has been already published, is a very interesting one, and the paper is one of the most valuable contributions yet made to the natural history of Australia. The excellent plates are to be especially commended.

One hundred and seven species were obtained by the *Thetis*, nine of which are new. These are: *Dasyatis thetidis*, *Chimæra orgilbyi*, *Anthias pulchellus*, *Monacanthus setosus*, *Sebastes* (rather Sebastodes)

thetidis, *Lepidotrigla modesta*, *Parapercis ocularis*, *Histiopterus farnelli*, and *Paralichthys tenuirastrum*. A new name, *var. elevatus*, is proposed for the Australian representative of *Macrorhamphosus scolopax*. Two new genera, Paratrachichtys (traili) and Pterygotrigla (polyommata, in place of Hoplonotus, preoccupied), are defined.

Perhaps the most interesting of the new forms is *Sebastodes thetidis*. That genus, now known to be represented by about fifty species off the coast of California and a dozen more in Japan, and a few off Chili, has its range thus extended southward to Australia. The new species is one of the extremes of the type, somewhat allied to *S. nigrocinctus*, but still more spinous about the head. In the present system it would be the type of a distinct subgenus, or possibly genus, standing at the very opposite extreme of the series from *Sebastodes paucispinis*, the original type of the genus.

The nomenclature and sequence adopted by Mr. Waite are thoroughly modern and in accordance with the law of priority. We may perhaps question the identity of the Australian horse mackerel with *Sarda chilensis* of Chili, or of the kingfish with *Lenola lalaudi* of Brazil. These identifications have been accepted by authors, the present writer among the number, but it seems better not to regard a species as cosmopolitan until actual comparison has shown it to be so. In most cases of this kind comparison of adequate material will show specific difference.

It is to be hoped that this very acceptable piece of work will be followed by many others until the natural history of Australia is thoroughly known.

D. S. J.

Smitt on Lycodes. — In *Annals and Magazine of Natural History*, Professor F. A. Smitt, of Stockholm, has a brief review of the species of Lycodes of the North Atlantic. He maintains that all specimens known to him are referable to four species. *Lycodes reticulatus*, vahlii, sarsii, and muræna. *Lycodes perspicillum* (*L. rossii*), he thinks, is the young of *L. reticulatus*, which is probably correct. *Lycodes frigidus* is a "mixture of sterile or deformed specimens" of vahlii and reticulatus. *Lycodes gracilis* is a northern variety of *L. vahlii*, with the head shorter (less than 22 per cent of total length; more than 22 per cent in typical vahlii). He suggests that *Lycodes muræna* is probably "a local or evolutional form of *Lycodes sarsii*." But that is about all that one could claim for any of the species in a group like Lycodes, in which the species are all closely related and vary much with conditions.

The characters of position of lateral line and numbers of pectoral rays used by Jordan and Evermann as a clue in this group are not noted by Dr. Smitt.

D. S. J.

Abbott on Chilean Fishes. — Mr. James F. Abbott, a graduate student of Stanford University, now teacher in a Japanese academy at Otsu, gives in the *Proceedings* of the Academy at Philadelphia notes on fishes collected at Valparaiso by Rear-Admiral Beardslee, U. S. N. Among these is a species of *Hippoglossina macrops*, which was originally, perhaps, incorrectly recorded as from Mazatlan. There is also a new species of Sebastodes, allied to *S. oculatus* and *S. darwini.* To this Abbott gives the name of *Sebastodes jenynsi.*

D. S. J.

Moreno on the Olfactory Nerves of Fishes. — In the *Annals of the Natural History Society of Madrid*, José Madrid Moreno gives an account of his studies of the olfactory nerves of fishes carried on in the laboratory at Naples. The anatomy of these nerves and their terminations is described in species of Scylliorhinus, Catulus, Scorpæna, Raja, Pagellus, and Serranus.

D. S. J.

California Water Birds — No. IV (*Proc. Cal. Acad. Sci. Zoöl.*, Vol. II, No. 3, 1900). — Mr. Leverett M. Loomis gives us the latest results of his studies on the migration of sea birds on the western coast of North America. The bulk of the paper consists of a detailed record of observations made at Monterey Bay and vicinity from Sept. 18, 1896, to Nov. 14 of the same year; but the portion of most interest, at least to the general zoölogist, is the discussion of the data obtained, and the conclusions drawn.

The following extracts will indicate not merely the results arrived at by the author, but as well the scope of his studies in this difficult but fascinating field; for the evidence on which the conclusions rest, the paper itself must be consulted.

"These investigations seem to prove (1) that the Shearwaters off Monterey find their position and shape their course by the landmarks; (2) that birds do not possess a mysterious superhuman faculty for determining direction, else the Shearwaters would not have been bewildered in the fog."

"It seems reasonable to conclude that young birds in the journey from their birthplace to the winter home of the species are dependent upon the guidance of the old birds who know the way, because they have traveled it."

"To sum up the whole matter in a single sentence: It is held that bird migration is a habit evolved by education and inheritance which owe their origin and perpetuation to winter with its failure of food."

W. E. R.

Ovogenesis in Tunicates. — Dr. F. W. Bancroft has published (*Bulletin of the Mus. of Comp. Zoöl.*, Vol. XXXV, No. 4, 1899) an extended account of his studies on the ovogenesis of *Distaplia occidentalis.*

In general, the development of the gonads and their ducts resembles that found in Perephora, Clavelina, and Ciona.

The most significant difference consists in the fact that the fundament of the ovotestis is present in the youngest stages in Distaplia, whereas in the other species it appears quite late in ontogeny.

To the question which type of ovary is more primitive, that represented by Clavelina, where there are two separate germinative epithelia, or that found in Distaplia with but a single such epithelium, the author is inclined to give the distinction to the Distaplia type, since here it occurs in a smaller and simpler species, and is itself simpler.

Dr. Bancroft goes at length into the question of the origin and fate of the test cells, discussing the whole matter in the light of the more recent statements by Davidoff and Salensky, based on their observations on *Distaplia magnilarva.* He does not confirm the results of these authors, and as his studies pertained to a species very closely related to the one studied by them; and, furthermore, as he had the opportunity, through the great courtesy of Professor Salensky, to examine slides of *D. magnilarva*, it would seem that his critical findings should be conclusive on this much discussed problem.

The function of these cells, the author believes, is to furnish nutriment to the growing ovum. He concludes that they are particularly active in this capacity in the early stages of the growth of the ovum, while the nucleus exerts its principal activity in the later stages in converting this nutritive material into yolk.

The germinative vesicle diminishes in size gradually and continuously with the increase in quantity of yolk in the ovum.

W. E. R.

Reproduction of Amœba. — In addition to the common and recurring bipartite division of *Amœba proteus*, Scheel[1] has described a

[1] Scheel, C. Beiträge zur Fortpflanzung der Amœben, *Festschrift zum siebenzigsten Geburtstag von Carl von Kupffer*, pp. 569–580, Pl. LI. Jena, 1899.

method of sporulation, or multiple reproduction, which takes place within a cyst formed by the animal itself. This cyst is thick-walled, spherical, and transparent, and, although without stalk or adhesive organ of any sort, it regularly sticks fast to small objects in the water, being found singly or in groups on sticks or stones. The series of changes were not observed in full, but the nucleus of the amœba is reduced by a series of direct divisions into a large number of daughter-nuclei. When this number has reached some five or six hundred the body of the amœba divides into as many independent daughter-individuals, and these are set free by the gradual decay and bursting of the cyst wall. A flagellate stage does not occur in *Amœba proteus*, but the spores enter directly upon the amœboid condition.

The causes of the multiple division in the encysted condition were not determined. The process is not related to sexual reproduction and apparently does not occur at regular intervals. Experiments by starvation, excess of food, evaporation of the water, and by transferring the animals to water from other localities, *i.e.*, by changed conditions of existence to bring the amœbas to encystment and sporulation, were uniformly without success. H. B. W.

Arctic Deep-Sea Fauna. — One of the most important results of recent Arctic exploration is the discovery of a true deep-sea fauna. An address delivered recently to the German Zoölogical Society by Dr. Schaudinn,[1] on the expedition made in 1898 by Drs. F. Schaudinn and F. Roemer to Spitzbergen, contains a preliminary report on this fauna.

This expedition set out to make collections in the Spitzbergen Sea, and successfully tried to reach the deep Arctic basin discovered by Nansen. This deep, called by Schaudinn the "Nansen Rinne," was reached north of Spitzbergen in 81° 32′, and a number of deep-sea dredgings were made. A true deep-sea fauna was discovered entirely different from the Arctic fauna of the shallow sea surrounding Spitzbergen (and from the other Arctic faunas hitherto known). Its most striking feature is the presence of an abundance of Hexactinellid sponges, a group never found previously in the Arctic regions, all of them belonging to new genera. These sponges are so plentiful that their remains form a very characteristic deposit on the bottom, composed of the spicules of the dead sponges closely connected and densely interwoven, so as to form a fine network, the meshes of

[1] Schaudinn, F. *Verh. Deutsch. Zool. Gesellsch.* (1899), pp. 227 ff.

which are filled with mud; after washing out the mud, about one-third of the volume remains as a glittering mass ("Glaswolle").

A detailed report on the peculiarities of this deep-sea fauna will be given in a separate work entitled *Fauna Arctica*, and will be, no doubt, one of the most interesting additions to our knowledge of the Arctic faunas.

A. E. O.

Arctic Marine Animals. — The material collected by the Princeton Expedition to North Greenland in 1899 has been sorted out, and part of it has been identified. It proves to be the largest collection of Arctic marine life ever made in the neighborhood of Inglefield Gulf and Smith Sound. Of the animals reported by former expeditions (Hayes, Nares, Peary Expedition of 1894), nearly every species is represented in the collection, while many additional species were taken which have not yet been recorded from these parts.

The chief value of this collection lies on the zoögeographical side, adding new localities to the known range of Arctic forms from parts hitherto almost unknown. These localities, situated so far north (76–79°), will be very valuable in the construction of a connection between many species now known from the Atlantic and Pacific parts of the Arctic seas. Some species seem to be truly circumpolar in distribution, while in others the connection seems to be interrupted. For the establishment of such cases an investigation of the fauna of this region as well as that of the northern coast of Siberia is necessary, and the collections of the Princeton Expedition to North Greenland, when published, will, in this respect, add considerably to our knowledge.

A. E. O.

Notes. — Dr. Thiele reports in *Fauna Arctica* a new solenogaster, *Proneomenia thulensis*, found by the German Arctic Expedition of 1898. It is characterized by a radula with many small teeth and by a multifid receptaculum.

In the Munich *Sitzungsberichte* Mr. A. M. Przesmycki reports his success in staining the nucleus of living Opalina and Nyctotherus with neutral red. The chromatin elements show the deeper color, and the phases of nuclear division may be watched in the living organism.

Text-books of zoölogy have made the statement that the mouth in the Infusoria is formed by the simple division of the parental organ. In the Heidelberg *Verhandlungen* Dr. A. Schuberg describes the origin of the peristomal region of *Euplotes patella* as a series of

extensive and complicated growth processes in which no simple plane of division can be recognized.

An interesting prorhynchid turbellarian from deep wells in New Zealand has been described by Haswell (*Quart. Journ. Micr. Sci.*, Vol. XL, pp. 631–645, Pl. XLVIII). It is most closely related to the Prorhynchidæ and not to the Alloiocœla, as at first believed. The complicated pharynx, the lateral vitello-germarium, and the unpaired lateral testis are among the important peculiar structural features of this form which the author includes provisionally in the genus Prorhynchus.

In an extended study of the morphology and physiology of *Euglena gracilis*, Zumstein (Inaugural-Dissert., Basel, 1899) shows that this species does not manifest anything of an animal method of life. Its nutrition may be purely holophytic, purely saprophytic, or both combined, but thrives best under the latter. The colorless variety of the species may be transformed into the green, or *vice versa*, with corresponding change in manner of nutrition.

The frequency of trematodes has been studied by Hausmann (*Centralbl. f. Bakt. u. Par.*, I. Abth., Bd. XXVI, pp. 447–453) in birds from Baden and the vicinity of Basel. The percentage of infection found was, Grallatores 29, Raptatores 26, Natatores 25, Corvidæ 24, which is from three to six times as large as numbers previously listed from birds.

Number IX of the third volume of the *American Journal of Physiology* contains the following articles: "On the Reactions of Chilomonas to Organic Acids," by H. S. Jennings; "Notes on the Individual Psychophysiology of the Crayfish," by G. V. N. Dearborn; "On the Artificial Production of Normal Larvæ from the Unfertilized Egg of the Sea Urchin," by J. Loeb; and "On the Maximum Production of Hippuric Acid in Rabbits," by W. H. Parker and G. Lusk.

In a reply (*Archiv f. die ges. Physiologie*, Bd. LXXIX, 1900) to a criticism of his paper on the psychic qualities of ants and bees, Albert Bethe tells us that the chief error in his work is that he did not distinguish clearly enough between objective expression and subjective "Empfindung" in our own psychological processes. He says that he agrees with Uexküll that the question concerning the Psyche of animals does not belong to the realm of exact science, and he declares that he is ever willing to discuss the question

whether or no ants and bees have the power to purposefully modify their acts (Modifications vermögen besitzen), and whether a "Remanenz" of a stimulus is possible in them. But whether they possess a psychical quality or not, he will not discuss, since the objective expressions of animals and the causes of these are all that legitimately belong to biological research.

W. E. R.

A supplementary part has been issued to Vol. XV of the *Journal of Morphology* and contains the following articles: "On Protoplasmic Structure in the Eggs of Echinoderms and some other Animals," by E. B. Wilson; "Studies upon the Early History of the Ascidian Egg," by H. E. Crampton; "The Spermatogenesis of Amphiuma," by J. H. McGregor; "The Calciferous Glands of the Earthworm, with Appendix on the Circulation," by N. R. Harrington; "The Changes in the Structure of the Pancreas Cell," by A. Mathews; and "The Spermatogenesis of Anasa tristis," by F. C. Paulmier. The supplement has a paging of its own, but is unaccompanied by a table of contents or title page.

BOTANY.

Phenological Observations in Canada. — Mr. A. H. Mackay[1] gives an account of some interesting phenological observations made in Canada during the seven years 1892 to 1898. This was one of the lines of work undertaken by the Botanical Club of Canada, and from nine to nineteen reports were received each year, giving more or less completely the time of the appearance of leaves, flowers, and fruits and the migration of birds. The author calls attention to the many difficulties of obtaining complete and accurate records; for example, the more rare species may easily escape notice until they have been in flower for some time. Again, some individual plants are earlier than others in the same locality, and in the same individuals certain branches are earlier than others, hence the records were made to include "first appearance" and "becoming common." A phenological date is defined as "a sort of mathematical function of variables," which is influenced by variations in temperature, of atmospheric pressure, sunshine, precipitation, together with the local constants, latitude, elevation, slope, proximity of bodies of water, and character of soil. The rapidity with which a season advances,

[1] *Canadian Record of Science*, vol. viii, pp. 71–84, 1900.

therefore, is governed "by the varying balance of the meteorological conditions affecting the organisms." A table is given of twenty objects most commonly observed, showing the average date for each of the seven years. From these the normal date or phenochron of each species is computed, together with the phenological norm or phenochron of the entire list for each year. Other tables are given of objects selected from different counties and provinces. If observers are symmetrically placed over a county, are competent and careful, and put the same interpretation on what constitutes "first appearance" and "becoming common," the averages would give phenological norms for the comparison of a very important character of the country with that of another, and more especially the comparison of one season with another in the same country, which, after a series of years, would contribute to the solution of the problem of secular variation of climate.

In 1897 the idea was extensively taken up in the schools of Nova Scotia as a part of the prescribed course in nature study, the pupils themselves making the observations under the guidance of the teachers. Hundreds of reports were sent in from as many school districts. It is believed to be a convenient means for the stimulation of pupils in observing all natural phenomena while going to and from school.

H. C. IRISH.

King's Irrigation and Drainage. — The high standard of excellence already established in the Rural Science Series under the editorship of Professor L. H. Bailey is fully maintained in the latest volume.[1] Although this volume is quite complete in itself, it may be regarded, in a way, as supplementary to Professor King's work on soils, with which the series began. Like that, the present work is addressed primarily to practical farmers and agricultural students, but at the same time it contains much of value to all interested in the nutrition of plants.

In an introduction of sixty-five pages the author discusses with considerable fullness the importance of water to the plant, and details some noteworthy experiments carried on by him at the University of Wisconsin to determine the quantity of water used by cultivated plants in coming to perfection under ordinary field conditions. The data thus obtained for various crops figure in impor-

[1] King, F. H. *Irrigation and Drainage:* principles and practice of their cultured phases. New York, The Macmillan Company, 1899. 12mo, xxii + 502 pp., 163 illustrations.

tant ways throughout the book. Part I, on Irrigation Culture, opens with an account, historically developed, of The Extent and Geographical Range of Irrigation. Then follow chapters on The Conditions which make Irrigation Imperative, Desirable or Unnecessary, The Extent to which Tillage may take the Place of Irrigation, and The Increase of Yield due to Irrigation in Humid Climates; then several chapters regarding the practical management of water under various conditions, and finally a chapter on Sewage Irrigation. Part II deals with the principles and practice of Farm Drainage.

In almost every chapter one finds an immense amount of information clearly displayed in tabular form and often representing the results of the author's experimental contributions to the subject. Then, too, one gains confidence in the author's general statements from the evident fact that they are based upon wide personal observation of irrigation and drainage practice, both in this country and in Europe. The author champions no pet theory; he lets facts speak for themselves and lead the way to broad principles of practical value.

The illustrations, largely reproductions from photographs, are, for the most part, of unusual excellence, and so reproduced as to show clearly the features intended to be seen.

F. L. S.

Trimen's Flora of Ceylon.[1] — Seven years ago, Professor Trimen, then director of the Royal Botanic Gardens of Ceylon, began the publication of a manual of the plants of that important island, which has now been brought to a conclusion in the fifth "part," or volume. The author lived to bring out only the first three volumes, and the other two have been seen through the press by Sir Joseph Hooker. To the concluding volume are appended a key to the orders, genera, and aberrant species of Ceylon flowering plants, with diagnostic characters of the orders; a chapter on the forests and waste lands of Ceylon, by A. F. Broun; a chapter on the distribution of the rainfall in Ceylon, by F. Lewis; a history of Ceylon botany, by G. S. Boulger; a table of corrections; and comprehensive indices to the entire work.

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[1] *A Hand-Book to the Flora of Ceylon.* Containing descriptions of all the species of flowering plants indigenous to the island, and notes on their history, distribution, and uses. By Henry Trimen. Continued by Sir J. D. Hooker. London, Dulau & Co., 1893–1900. 5 vols., 8vo.

Nuclear Phenomena in Ustilagineæ. — Contributions such as Professor Harper presents[1] have been few, but are much needed to explain this class of plants. He studied, in particular, the germination, growth, divisions, and fusions of *Ustilago antherarum* and *U. Scabiosæ.* He finds that in fusions of conidia, which are apparently caused by chemotactic stimuli, no nuclear changes take place, yet the cytoplasmic union of the cells causes them to increase in size, and gives them power to resist unfavorable conditions. It may be a primitive or degenerate sexual union.

J. B. S. NORTON.

Cell Division in Sporangia and Asci.[2] — Dr. Harper has contributed another very valuable investigation upon the morphology of the structures named. Among the Phycomycetes he has studied spore formation in sporangia of Synchitrium, Pilobolus, and Sporodinia, and for comparison, ascospore formation in *Lachnea scutellata* among the Ascomycetes, in which he was able to find stages undiscernible in his previous work on Peziza and Erysiphe.

In Synchitrium he regards the uninucleated cell as the vegetative body of the plant, the supervening multinucleate condition constituting, in his view, a sporangium rather than a thallus body. Cleavage by invagination of the plasma membrane follows this multinucleation, the contents of the "sporangium" being segmented, from without inward, into irregular plasma masses containing numerous nuclei. This cleavage resembles what is seen in some insect eggs. The segmentation of the protoplasm does not occur by repeated bipartitions or by the formation of walls, simultaneously, about the several nuclei. Orientation with respect to the nuclei is not evident at first, but becomes apparent later, in the final subdivision of the contents of the sporangium into uninucleate plasma segments. A shrinkage then occurs, followed by increase in size of these "protospores" and the subsequent repeated division of their single nuclei, to form from eight to twelve or more in a single "protospore." The number of them is not definite as in the ascus, but seems to depend, according to Harper, on the individual conditions of nutrition in the different "protospores."

Substantially the same cleavage process of spore formation was observed in three species of Pilobolus and in Sporodinia. There is nothing in the process of spore formation described in the Phycomy-

[1] Harper, R. C. Nuclear Phenomena in Certain Stages in the Development of the Smuts, *Trans. Wis. Acad. Sci.*, vol. xii, pp. 475–498, Pls. VIII, IX. October, 1899.

[2] R. A. Harper, in *Annals of Botany*, December, 1899.

cetes which at all resembles the free cell formation in the ascus, where the spores are cut out of the ascus plasm by the revolution of the aster rays. In the Phycomycetes we have isolation of the "protospores" by successive irregular segmentations, not simultaneous, but progressive. "This progressive segmentation has no parallel in the asci, where from the start a single nucleus forms the center for the formation of each daughter-cell" (p. 517). Harper finds it possible to connect the cleavage processes of the Phycomycetes with other cases of division by constriction, as in cell division in Cladophora, or in the abstriction of conidia in Erysiphe, as described by him, but he finds no connecting link between this general process of spore delimitation and free cell formation in the ascus. This stands as opposed to the older view of Brefeld that the ascus merely represents an evolution out of the ancestral sporangium, from an indefinite to a definite number of spores of definite size and form. Moreover, in the origin and character of the "epiplasm," regarded as a distinctive feature of the ascus, and that of the "episporal slime" of the sporangium, Harper finds no connection whatever. A possible origin of the processes seen in the ascus is suggested tentatively in such phenomena as Strasburger described (*Zellbildung und Zelltheilung*) for swarm-spore formation in Œdogonium. This, however, the author has not as yet been able to confirm by personal investigation.

The general conclusion is that the Ascomycetes cannot have arisen from the Phycomycetes, — the ascus seems to stand by itself as a peculiar structure, whose origin is at present in obscurity, — and, finally, the author's researches, together with those of Thaxter on the Laboulbeniaceæ, seem to point very strongly to a multiple algal origin of the fungi and the subsequent independent evolution of certain forms of spore production by different groups.

H. F. Roberts.

Notes. — The Cactaceæ of the Galapagos Islands are passed in review, by Dr. Albert Weber, in the *Bulletin* of the Paris Museum for 1899, and four species are recognized, of which two, pertaining to the genus Cereus, are characterized as new, while the other two, belonging to the genus Opuntia, were described and named in 1898.

A. Purpus, of the Darmstadt Botanical Garden, publishes an article on North American cacti which have proved hardy in Germany, in *Die Gartenwelt* of January 7. Several reproductions from photographs represent the species referred to.

Dr. Schumann contributes an article on the art of collecting cacti to the *Notizblatt* of the Berlin Botanical Garden of December 29.

Parsonsia paddisoni, a new apocynaceous plant yielding large edible tubers, is described by R. T. Baker in No. 95 of the *Proceedings of the Linnæan Society of New South Wales*, which contains several other papers of botanical interest.

The botany of New Zealand receives fourteen contributions, covering various groups of flowering plants and cryptogams, and abundantly illustrated, in the twenty-third volume of the *Transactions and Proceedings of the New Zealand Institute*, the frontispiece for which is a portrait of the veteran botanist Colenso.

A study of the seed dispersal of *Pinus sylvestris* and *Betula alba*, the results of which are published by Robert Smith in the *Annals of Scottish Natural History* for January, shows that the seeds of the former have been effectively carried by the wind to a distance of 886 yards, and of the latter to a distance of 489 yards, from the parent trees.

The most imposing brochure of the first volume of the *Proceedings of the Washington Academy of Sciences*, the publication of which has just been concluded, and the form, typography, illustration, and make-up of which constitute a model worthy of the study of all publishing bodies, is devoted to a description of a new genus and twenty new species of fossil cycadean trunks from the Jurassic of Wyoming, by Professor Lester F. Ward.

The geographical distribution of *Solanum carolinense*, *Tribulus terrestris*, and *T. maximus*, is discussed by Pammel in *Bulletin No. 42* of the Iowa Agricultural College.

The lime content of the soil, which plays an important rôle in the growth of certain plants, has been carefully worked out about Cognac by Guillon, whose results, with especial reference to viticulture, are given in the *Revue de Viticulture* for January 6, with the aid of a colored map.

The "Report on the Progress of Pharmacy," in the *Proceedings of the American Pharmaceutical Association* for 1899, contains a large amount of information, tabulated by plant families, which is not likely to be found so readily elsewhere by botanical students.

The results of all available American chemical analyses of nuts, and a discussion of the value of nuts as food for man, are contained in *Bulletin No. 54* of the Maine Agricultural Experiment Station.

Farmers' Bulletin No. 108 of the Department of Agriculture at Washington deals with saltbushes, — plants adapted to salt or alkaline regions, — and is written by Dr. P. B. Kennedy.

The *Bulletin de l'Herbier Boissier*, under the editorial care of M. Autran, curator of the herbarium which was founded by Boissier and is maintained near Geneva by M. Barbey, suspends publication on the conclusion of Vol. VII. It is to be continued by a series of octavo *Mémoires*, the first of which, a continuation of Professor Schinz's "Pflanzenwelt Deutsch-Südwest-Afrikas," was issued on Jan. 15, 1900.

An interesting account of the one-time London Botanic Garden, established by Salisbury in 1807, and the later history of which seems to have passed into oblivion, is given by W. Roberts in the *Gardeners' Chronicle* of February 3.

The *Gardeners' Chronicle* of February 24 contains a figure of the monument to David Douglas in the parish churchyard at Scone and a transcript of the inscription which it bears, as well as a portrait and short biographical sketch of this interesting man, of whom it has been said that no other collector has ever reaped such a harvest in America, or associated his name with so many useful plants, and that nobody, not even Fortune, has conferred so much honor on the Royal Horticultural Society, and so much benefit to horticulture in general as regards the importation of plants.

A good portrait of Professor A. S. Hitchcock, who is this year Director (or President) of the Académie Internationale de Géographie Botanique, is issued with the March *Bulletin* of that organization.

The first fascicle of Vol. XVII of *La Cellule* has as frontispiece a portrait of the late Professor J. B. Carnoy, and contains the address delivered at his funeral by Dean Gilson of the University of Louvain.

Portraits of the Tulasne brothers form the frontispiece to Vol. XVI of the *Bulletin* of the Société Mycologique de France.

Dr. Willis, Director of the Royal Botanic Gardens at Peredeniya, Ceylon, calls attention to the new research station of that important establishment, in the *Botanical Gazette* for March. The facilities of the garden are freely offered to competent investigators.

The March number of the *Journal of the New York Botanical Garden* contains an interesting account of the herbarium of the New York Garden and of its new home.

The genus Cratægus receives a further accession of eleven new species for the Eastern States in a contribution by W. W. Ashe to the *Journal of the Elisha Mitchell Scientific Society*, published in February.

The results of an experimental study by Henseval of abrine, the highly toxic albuminoid of *Abrus precatorius*, are published in the current volume of *La Cellule.*

Cereus mojavensis, one of our interesting desert cacti, is figured in the *Botanical Magazine* for March.

A revision of the species of Plantago commonly referred to *P. Patagonica*, by E. L. Morris, appears in the *Bulletin of the Torrey Botanical Club* for March, and apparently contains the results of careful study.

The North-American species of Chætochloa are revised by Scribner and Merrill in *Bulletin No. 21* of the Division of Agrostology of the United States Department of Agriculture.

In a note in the *Journal of Botany* for February, Dr. Masters states that while the *Glyptostrobus pendulus* of English gardens is merely a variety of *Taxodium distichum*, there is a true Glyptostrobus, which, while in garden specimens that have not yet reached the fruiting age cannot be separated from Taxodium, is yet amply distinct when fruiting, in its elongated (not peltate), cone-scaled and evidently winged seeds.

A supposed bigeneric hybrid between *Cystopteris fragilis* and *Asplenium Trichomanes* is described from the Jura by Parmentier in the *Bulletin de l'Académie Internationale de Géographie Botanique* for February.

A catalogue of the flora of Montana and the Yellowstone National Park, by Dr. Rydberg, constitutes the first volume of the *Memoirs of the New York Botanical Garden* — a volume of nearly 500 pages, issued in February, 1900.

An analytical list of the plants of Rovereto is published by Professor Stefani in Vol. V of the *Atti della I. R. Accademia . . . degli Agiati*, and should be of use to visitors to the region of the Adriatic.

A botanical bibliography of the Argentine Republic is reprinted by F. Kurtz from Vol. XVI of the *Boletin de la Academia Nacional de Ciencias de Córdoba.*

Among the applications of photography now being presented in *The Process Photogram* of London, that of recording tree forms, in the March number, is of interest to botanists, since, as the editor says, it is truly "a very difficult task to give a photographic account of a tree."

PETROGRAPHY.

The Petrographical Province of Essex County, Mass. — A very careful and critical study of the igneous rocks of Essex County, Mass., is given us by Washington[1] in a recent series of papers in the *Journal of Geology.* The district "is characterized as one of rocks which are more acid or more basic than normal, high in alkalis, with Na_2O predominating over K_2O, high in iron oxides, especially FeO, rather high in Al_2O_3, and low in MgO and CaO." The rock types recognized are granites, quartz-syenites, diorites, essexites, gabbros, rhyolites, and the dike rocks, aplite, microgranite, diabase, paisanite, and camptonites. The essexites embrace also pulaskites and litchfieldites, characterized by the presence of albite, nepheline, ægirite, and alkaline amphiboles.

All these rocks are regarded as differential phases of a laccolitic mass, with a composition approximating that of an acid diorite.

The first differentiation of this magma is thought to have given rise to the granites, syenites, diorites, and the granito-diorite dikes, and a further local differentiation of the basic forms to foyaites, essexites, and paisanite-tinguaite dikes.

Each of the rock types occurring in the district is carefully described, and of each a chemical analysis is given. The work is thorough. As the result of the paper, Essex County becomes one of the best known petrographical provinces in the country.

The two most interesting dike rocks[2] of the district are a glaucophane-sölvsbergite containing cordierite, and an analcite-tinguaite. Analyses of these two rocks follow:

SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O	H_2O	P_2O_5	Ign.
64.28	.50	15.97	2.91	3.18	.03	.85	7.28	5.07		.08	.20 = 100.33
56.75	.30	20.69	3.52	.59	.11	.37	11.45	2.90	.04	Cl = .28	3.18 = 99.92

Nepheline-Syenites. — The corundum-bearing nepheline-syenites of Ontario are of such economic interest that the Canadian official

[1] *Journ. of Geol.*, vol. vi, p. 787, and vol. vii, pp. 53, 105, 284, and 463.

[2] *Amer. Journ. Sci.*, vol. vi, 1898, p. 176.

geologists have recently carefully examined them. Coleman [1] describes an exposure on the New York branch of Madawaska River, in Dungannon township, as a light and gray banded rock cut by a pegmatite dike composed of large crystals of nepheline and muscovite. In the syenite are nepheline, albite, oligoclase, labradorite, orthoclase microcline-biotite, scapolite, calcite, muscovite, and occasionally augite and apatite. Corundum is also present, as small grains and large crystals usually associated with muscovite. Specimens obtained from exposures in other portions of Dungannon and neighboring townships present variations from the rock referred to above, but they are not of special significance.

In one case, however, a medium-grained white rock from Methuen, Peterboro County, consists essentially of a plagioclase, more acid than the plagioclase of the anorthosites.

The corundum in these rocks is thought to represent the excess of Al_2O_3 that existed in a magma supersaturated with alumina, but not saturated with silica.

Miller [2] outlines the situation of three belts of the corundiferous rocks. These rocks, like those referred to by Coleman, are syenites, nepheline-syenites, and an anorthosite. The last-named rock was analyzed, with this result:

SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	Na_2O	K_2O	CO_2	Tot.
26.24	29.85	1.30	2.12	16.24	2.41	1.98	.18	1.03	= 101.35

Its feldspar has the formula Ab_1, An_4, *i.e.*, it is a bytownite. The rock is from the Seine River.

Another occurrence of nepheline syenite in New Jersey is added by Ransome [3] to those already known in the State. The rock forms a portion of the trap mass of Mt. Gilboa, near Brookville, which is intrusive in Triassic beds. The constituents of the syenite are: orthoclase, anorthoclase, and other feldspars, nepheline, hornblende, ægirine, biotite, cancrinite, muscovite, analcite, natrolite, apatite, fluorite, and calcite, the last six named, with the exception of apatite, being secondary. An analysis gave:

SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	BaO	MgO	K_2O	Na_2O	H_2O	F
54.68	.79	21.63	2.22	2.00	2.86	.05	1.25	4.58	7.03	2.15	.22

SO_3	P_2O_5	Total	Less O = F	
.07	.28	99.81 –	.09	= 99.72

[1] *Journ. of Geol.*, vol. vii, 1899, p. 437.
[2] *Amer. Geol.*, vol. xxiv, 1899, p. 276.
[3] *Amer. Journ. Sci.*, vol. viii, p. 417.

With this syenite are also associated a biotite and a hornblende-syenite and a hornblende-granite. The major portion of the trap mass is a fine-grained hypersthene-gabbro. The relation of the syenites to the trap could not be discovered.

Notes. — The granite-gneiss near Middletown, on the Connecticut River, is, according to Westgate,[1] an igneous rock. The rock is a biotite gneiss, often containing eyes of feldspar consisting of cores of single orthoclase crystals enclosing grains of other feldspars, and sometimes surrounded by peripheral zones of a granular feldspar.

A second series of analyses of Italian volcanic rocks is presented by Washington.[2] Among them is an analysis of ciminite from La Colonetta, on the south slope of Monte Cimino; one of the "mica-trachyte," or selagite, from Monte Catini, Tuscany; one of an andesite from Radicofani, Tuscany, and one of the well-known leucitite of Capo di Bove. The analyses of the ciminite (I), the selagite (II), and the leucitite (III), follow:

SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	BaO	Na_2O	K_2O	H_2O	Tot.
57.31	.40	14.71	1.21	4.37	7.80	6.90		1.35	6.38	.18	= 100.61
56.39	2.07	12.88	2.36	3.54	7.83	4.06		1.30	7.84	1.33	= 99.60
45.99	.37	17.12	4.17	5.38	5.30	10.47	.25	2.18	8.97	.45	= 100.65

The ciminite analysis differs from the original analysis of Washington's type rock in showing less Al_2O_3 and more MgO. The difference in the two analyses is explained as due to incomplete separation of the two oxides in the earlier analysis. The selagite appears to be a minette-like form of ciminite, differing from the latter in possessing biotite in place of olivine and orthoclase.

An excellent description of the titaniferous iron ores of the Adirondacks appears from the pen of J. F. Kemp.[3] The ores are shown to contain small quantities of hypersthene, augite, plagioclase, and many of the other constituents of gabbros. From their close association with rocks of this class, the author regards the ores as differentiation products of their magmas, in the same way that the titaniferous ores of Minnesota, of Sweden and Norway, and of other places are believed to be varietal phases of a similar magma. Incidentally, the paper describes a few gabbros and anorthosites from near Lake Sandford, in Newcomb township.

[1] *Journ. of Geol.*, vol. vii, 1899, p. 638.
[2] *Amer. Journ. Sci.*, vol. ix, 1900, p. 44.
[3] *Nineteenth Ann. Rept. U. S. Geol. Surv.*, Pt. iii, p. 377.

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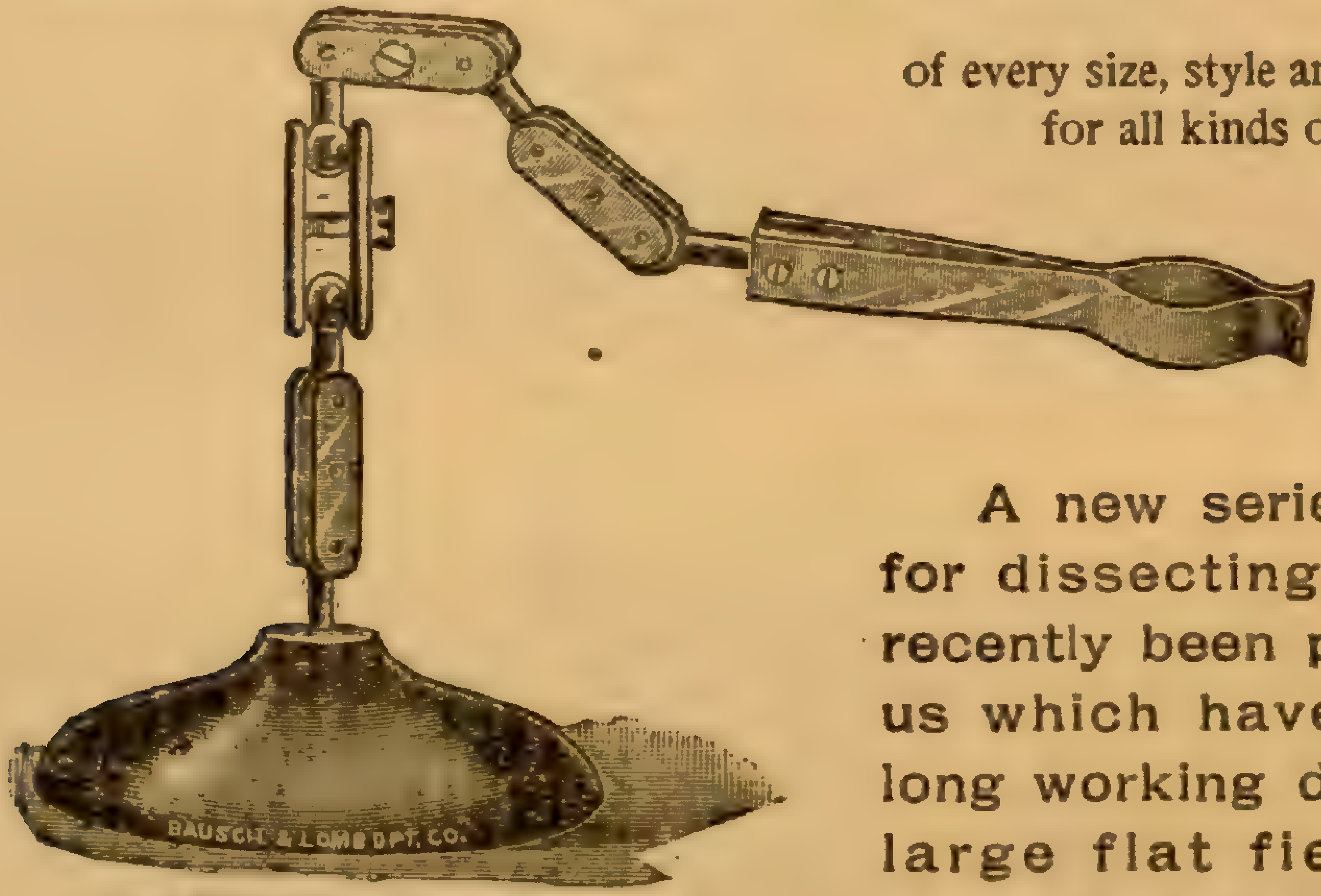

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CONTENTS

			PAGE
I.	The Neurone Theory in the Light of Recent Discoveries	Professor G. H. PARKER	457
II.	Variation in the Venation of Trimerotropis	Professor JEROME McNEIL	471
III.	Notes on the Mammals of Prince Edward Island	ROBERT T. YOUNG	483
IV.	The Cactus Bees; Genus Lithurgus	Professor T. D. A. COCKERELL	487
V.	The Advance of Biology in 1897	Professor C. B. DAVENPORT	489
VI.	On the Interpretation of Unusual Events in Geologic Records Illustrated by Recent Examples	Professor F. W. SIMONDS	495
VII.	Synopses of North-American Invertebrates. X. The Oxyrhynchous and Oxystomatous Crabs of North America	MARY J. RATHBUN	503
VIII.	Reviews of Recent Literature: *Anthropology*, The Races of Man — *Zoölogy*, The White-Fish of Lake Chapala, Evermann on Species and Subspecies, Smith on the Fishes of Woods Holl, Eigenmann on Blind Vertebrates, Microbdella biannulata, Locomotion of Solenomya, Ear Bones, Otocysts of the Heteropods, Capillaries and Sinusoids, Villi of the Mammalian Intestine, Notes		521 523
IX.	News		529
X.	Note on Cestode Nomenclature	Professor H. B. WARD	533
XI.	Publications Received		534

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THE

AMERICAN NATURALIST

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THE NEURONE THEORY IN THE LIGHT OF RECENT DISCOVERIES.[1]

G. H. PARKER.

The nervous system differs from all other systems of organs in that its cellular elements show the highest degree of differentiation. Thus, in the digestive system, the destruction of a few liver cells means only a minute diminution in the amount of bile secreted, a loss that can be entirely replaced through the slightly increased activity of the remaining cells; and in the muscular system the removal of a few muscle fibres from a given muscle may be made good physiologically by a minimal increment of work from the remaining fibres; but the loss of a few or even of a single sensory cell in the retina will produce a blind spot in that organ which no amount of activity from the adjoining cells, aside from possible regeneration, can ever replace. Each sensory cell in the more efficient parts of the retina has a function dependent upon its position and, therefore, different from that of any neighboring cell; and, while this may not be absolutely true of all parts of the nervous sys-

[1] A lecture delivered before the Section of Biology of the New York Academy of Sciences, Jan. 29, 1900.

tem, it is vastly more characteristic of nervous structures than of any other organs in the body. While in most systems differentiation may be said to have reached the gross organs, in the nervous system it has extended beyond this to the cellular elements. It follows, therefore, that to know the nervous system anatomically a study of its gross organs is not sufficient; we must know its cellular composition. Hence it is that our more fundamental knowledge of the structure of nervous organs is a product of the present century, the century of cellular research.

Although the enunciation of the cell doctrine by Schwann in 1839 was accompanied with a remarkably full description of the cellular components of most animal tissues, including the nervous, it was not until over half a century later that a consistent cellular analysis of nervous organs was accomplished. This was set forth in the conception of the neurone as advanced by the Berlin histologist and anatomist Waldeyer in 1891. The theory of the neurone can best be approached by reviewing briefly the historical steps that lead up to it.

While it is possible that some of the earlier microscopists, and particularly the Scotch anatomist Monro, were acquainted with nerve fibres, the first unquestionable description of these structures was given by Fontana (**1781**), and Stieda, who has reviewed this subject with much care, justly designates this Italian physician as the discoverer of nerve fibres. Fontana's discovery, which for some time failed of the recognition that it deserved, was eventually confirmed by Treviranus (**1816**) and particularly by Ehrenberg (**1833**), whose studies showed that the central nervous organs, as well as the peripheral nerves, were composed of definite fibres. Fontana's work may be regarded as the first step in the modern portrayal of the finer anatomy of nervous organs in that it is the earliest unquestionable description of nerve fibres.

Ehrenberg in the narration of his discoveries not only described and figured nerve fibres, but he also gave an account of other microscopic bodies found in nervous organs, such as crystals, blood corpuscles, and certain roundish bodies which he called "Kugeln" and which subsequent investigators termed

ganglion cells. In 1836 Valentine described these ganglion cells with much care, and two years later Remak claimed that in the sympathetic nervous organs of vertebrates ganglion cells were directly connected with nerve fibres. This proposition was supported and broadened by Helmholtz in 1842, who maintained that what Remak had claimed for the vertebrates was also true for invertebrates. Seven years later, in 1849, Kölliker in the first volume of his newly established *Zeitschrift für wissenschaftliche Zoologie* pointed out the inconclusiveness of the observations of Remak and of Helmholtz. The fibres that these authors had described as arising from ganglion cells were marked in no way as indubitable nerve fibres. Doubtless they were nerve fibres, but the histological knowledge of that day, as Kölliker rightly maintained, did not preclude them from being fibres of another kind. Kölliker then proceeded to show that, in the central nervous organs of vertebrates, ganglion cells could be found that were directly connected with fibres possessing medullary sheaths. As medullary sheaths are found only on nerve fibres, it follows that Kölliker's demonstration was the first in which it was shown beyond doubt that nerve fibres are directly connected with ganglion cells. The connection thus demonstrated made it clear that from this time on ganglion cells as well as nerve fibres must be reckoned as essential parts of nervous organs. This may be said to be the second step in the development of our ideas on nervous tectonics.

The third step in this direction was taken by the histologist Leydig, who, in describing the finer anatomy of the arthropods in 1855, stated that the central nervous organs of the spider contained, in addition to ganglion cells and nerve fibres, masses of material composed of many very fine interlacing fibrils. The minutely granular appearance of this material led Leydig to call it "Punktsubstanz," though he did not commit himself to the idea that it was granular rather than finely fibrous. In 1872 Gerlach, by the use of gold chloride, discovered an essentially similar material in the central nervous organs of vertebrates, and, while he assumed for this material a network structure rather than a simple interlacing of fibrils, the facts that he had at hand were in reality much the same as Leydig

had previously presented. In both vertebrates and invertebrates it was early recognized that this finely fibrous material was directly continuous with the living substance of both nerve fibres and ganglion cells, and therefore formed an integral part of the nervous organs. To this substance, whether it be from vertebrates or invertebrates, His gave the convenient name of "neuropile."

As no other material aside from the three thus far considered has been found to be necessarily connected with nervous organs, we may regard such organs as made up of a combination of nerve fibres, ganglion, or, as they are often called, nerve cells, and neuropile. The mutual relations of these three materials must next be considered.

The problem of the relation of these nervous materials has been discussed chiefly from the standpoint of the anatomical origin of nerve fibres. When a nerve fibre is traced into a central nervous organ, from what is it found to take its origin? Does it pass out from a ganglion cell, does it originate from the neuropile, or does it come from some other source? This is what is meant by the anatomical origin of nerve fibres, and, on this question the earlier neurologists were divided into three schools. First, there were investigators, like Buchholz, who attempted to maintain that all nerve fibres arose directly from ganglion cells. Next, there were those who, with Leydig at their head, believed that nerve fibres were formed by a drawing together of many fibrils in the neuropile, whereby the transmitting core of a fibre was established. The advocates of this view also believed that the fibrils of the neuropile were derived from the finely divided processes of ganglion cells, and that, therefore, nerve fibres were connected with ganglion cells through the neuropile. Hence they rightly designated their view as that of the indirect origin of nerve fibres as contrasted with the origin of these structures directly from ganglion cells. Finally, there were those who, like Gerlach, maintained that both methods of origin occurred, *i.e.*, that some fibres arose directly from cells and others indirectly through the neuropile. In support of this opinion Gerlach instanced the condition of the spinal nerves in vertebrates (Fig. 1), in which the dorsal

fibres spring from the neuropile, *i.e.*, have an indirect origin, and the ventral fibres arise directly from ganglion cells in the ventral horn of the cord. This example was practically conclusive, and later neurologists have been generally free to admit that nerve fibres differ as to their mode of origin, some coming directly from cells, others indirectly, *i.e.*, from the neuropile.

All-absorbing as many of the neurologists of the past found this problem of the anatomical origin of nerve fibres, its solution was followed by no important generalizations. This is probably due to the fact that the views of both the principal

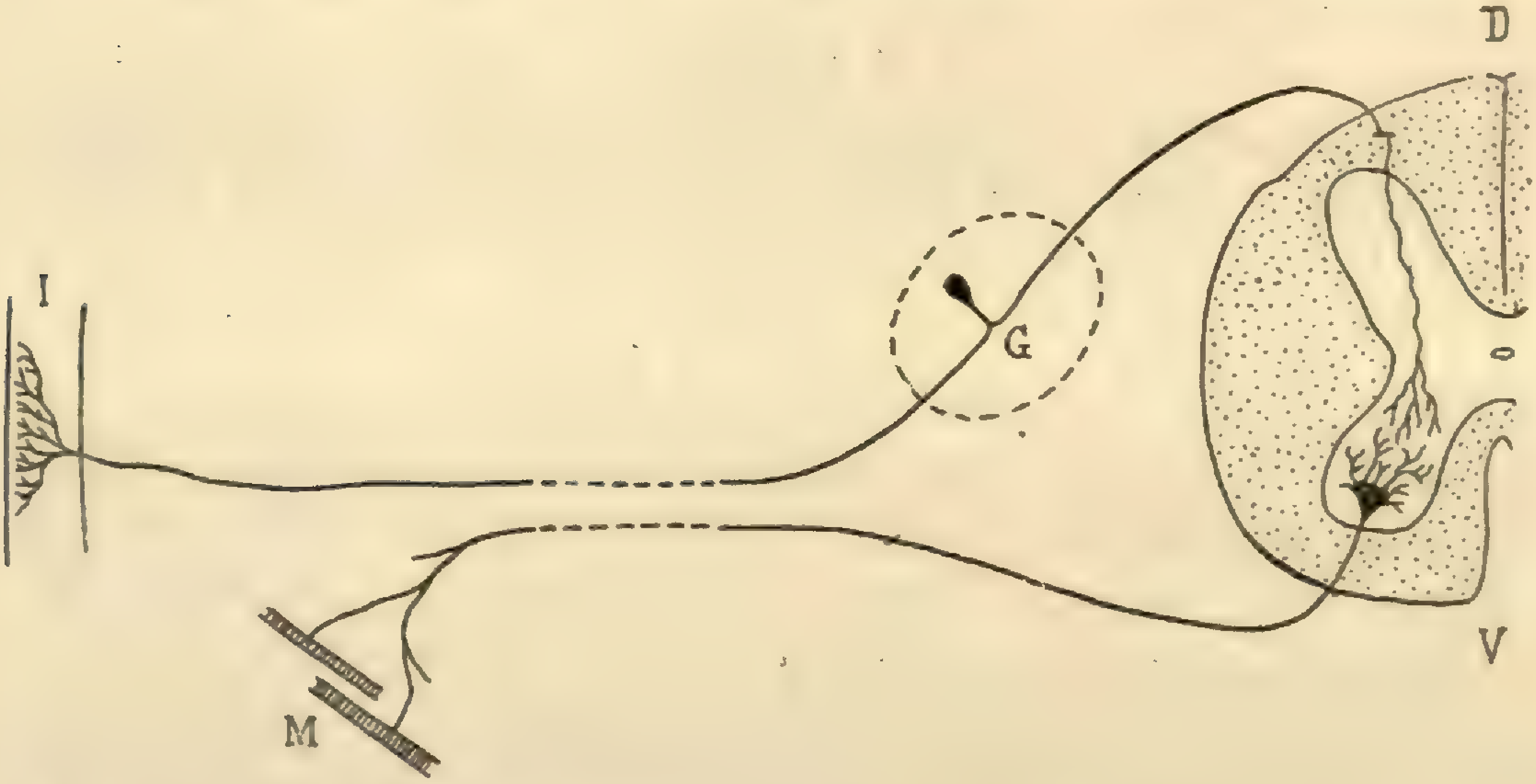

Fig. 1. — Ideal transverse section of vertebrate spinal cord illustrating the extent of a dorsal and of a ventral neurone. The dorsal neurone begins in the integument (*I*), has its cell body situated in the dorsal ganglion (*G*), and enters the cord at the dorsal side (*D*). The ventral neurone has its cell body in the ventral part of the cord (*V*) and is distributed peripherally to muscle fibres (*M*).

contending parties proved to be correct, and the whole conflict, like the inconclusive battles of military history, was lost sight of. But the mass of observations accumulated in the discussion of the anatomical origin of nerve fibres was destined to become a soil from which new growth was to spring. The change that now came over this field of inquiry was in part due to the invention of two new methods of research, Golgi's silver impregnation method and Ehrlich's methylen-blue staining, and in part to a new way of looking at old problems, which, though vastly stimulated by the results obtained through the new methods, was in a measure independent of these. It is note-

worthy that this new departure was initiated to a large extent by one of the oldest working neurologists, Kölliker, who, in his presidential address, delivered before the Anatomische Gesellschaft at Munich, in May, 1891, pointed out the relative unimportance of the problem of the anatomical origin of nerve fibres and raised the really vital question, Is there any nerve fibre not directly connected in some part of its course with a ganglion cell? To this question Kölliker gave a negative reply, and this reply has been confirmed by all subsequent investigators. Every nerve fibre, be it of direct or of indirect origin, is somewhere in its course directly connected with a ganglion cell. In the vast majority of cases the fibres are associated each with a single cell and no more; but in some instances, as, for example, among the worms, fibres are known to be directly connected with several cells.

Kölliker's generalization contains the germ of the neurone theory and leads at once to the statement of that theory as made by Waldeyer in an address before the Berliner medicinische Gesellschaft in June, 1891. This may be stated as follows: The nervous system is not correctly described as composed of nerve fibres, ganglion cells, and neuropile, but it is composed of nervous cells whose bodies we recognize as ganglion cells and whose processes are the cores of the nerve fibres and the neuropile directly connected with these cells. The nervous system then is made up of units, each one of which consists of a ganglion cell provided with longer or shorter processes, the cores of the nerve fibres, and producing from its surface and from that of its fibres fine fibrils, which collectively constitute its neuropile and which bring it into physiological connection with other such units. To these nervous units Waldeyer gave the name "neurones," and the belief that neurones are the structural elements of the nervous system constitutes the neurone theory.

It must be plain from what has been said that each neurone is nothing more than a modified cell. It is characterized, as a rule, by the possession of only one nucleus, and its most obvious peculiarity is that its cytoplasm is in part drawn out into very delicate and enormously elongated processes, the cores of

the nerve fibres. If the neurone is only a cell, it should then show the general properties of a cell, and it is from this standpoint that the neurone theory has been most satisfactorily tested. In this connection it is necessary to examine briefly the development of nerves, the degeneration and regeneration of nerves, and the nature of the neuropile.

The development of a nerve was early sketched by Remak (**1836**) and by Schwann (**1839**) ; both maintained that each fibre consisted of a series of cells fused end to end. This view was accepted by many later investigators, notably by the English embryologist Balfour, who showed that in the elasmobranch fishes the nerve fibres were early represented by lines of cells. This hypothesis of the chain structure of nerve fibres was not, however, without its opponents. Von Kupffer seems to have been the first to catch the idea that at least the core or axis cylinder of a nerve fibre was an outgrowth from the ganglion cell. This view was subsequently supported by others, especially by His, whose brilliant investigations on the development of the nerves show beyond a doubt that the axis cylinder is an outgrowth from a ganglion cell (Fig. 2). The forming axis cylinders may become surrounded by cells that eventually develop into the sheath cells of the fibre, and these undoubtedly formed the lines of cells mistaken by many investigators for developing nerve fibres. The resolution of a nerve fibre into a chain of cells, as implied in Remak's original description, is entirely at variance with the neurone theory, but the establishment of the idea that the essential part of every nerve fibre, the axis cylinder, is an outgrowth of a ganglion cell is in perfect accord with it. In the development of its parts, the neurone acts as a single cell; its processes, the axis cylinders of the nerve fibres, are its outgrowths.

FIG. 2. — Transverse section of the ventro-lateral wall of the developing spinal cord of a chick (in part after Ramon y Cajal). Four cells are shown in process of forming the axis cylinders of future nerve fibres. The outgrowths from the two middle cells have extended beyond the limits of the cord; those of the two other cells still lie within that structure.

The degeneration and regeneration of nerves also afford an

opportunity of testing the theory. It has long been known that when a nerve is cut or a bundle of fibres in a central organ injured, some fibres degenerate in one direction, some in another. The question naturally arises, do these degenerations take place in accordance with the assumed cellular nature of the neurone?

Experiments upon large protozoans have shown that when these unicellular animals are cut in two so that one part, which may be the smaller, contains all the nucleus and the other is without even a fragment of this organ, the part without the nucleus invariably soon dies, while that which retained the nucleus may regenerate the lost part and continue to live. The nucleus is in some way absolutely essential to the continued life of the cell.

The same is true of nerve fibres. If a nerve be cut, that portion of each fibre which is thus severed from the nucleus-bearing part, the so-called ganglion cell, invariably dies, even though it remains among the tissues of the body and is bathed in the fluids that are presumed to nourish it. This rule holds for all the degenerations of the nervous organs; after severance the non-nucleated portions of the neurones degenerate precisely as the non-nucleated portion of the protozoan body degenerates. The degeneration of nerve fibres then takes place in accordance with the conception of the neurone as a single cell.

Precisely as the nucleated portion of the divided protozoan body continues to live and may regenerate its lost parts, so the nucleated portion of the neurone remains alive, and, if the injury has not been too severe, may reëstablish itself by throwing out new axis cylinders from the cut end of the old one, and thus new fibres may by growth reëstablish many of the former connections. Regeneration in the neurone, as in the protozoan cell, takes place from the nucleated part; and this phenomenon, as well as that of degeneration, points very clearly to the conclusion that the nucleus of the neurone, like that of any other cell, is a center on which the life of even the most remote portion of the cell is dependent.

This conclusion leads us directly to an important interpre-

tation of the neuropile. If the nucleus of each neurone is a center from which the life of the whole neurone is controlled, then this control must extend, in the case of a given neurone, over that portion of the neuropile associated with it; in other words, the neuropile cannot be considered a diffuse network, as claimed by Gerlach, but must be regarded as divided into provinces, each one of which is under the rule of the neurone with which that particular part is associated (see Fig. 1). The boundaries between these provinces must, then, mark the real limits of the neurones, and that such boundaries actually exist, at least in a physiological sense, is to be inferred from two classes of observations. First, in the degeneration of the central fibres of one of two intimately associated sets of neurones, the degeneration proceeds into the neuropile but not across it, showing that the separation of the neurones lies somewhere in that material. Secondly, since the embryonic cells from which neurones finally develop are in the beginning often widely separated from each other, it follows that their association must be brought about by their gradual growing towards each other, and, as their first step in union would be that of the simple contact of their neuropile masses, it is possible that this relation is all that ever exists and that the points of separation in the neuropile are the original contact points of the developing neurones. For this ingenious suggestion we are indebted to the Swiss neurologist Forel, who, with a keen appreciation of the significance of the embryological investigations made by His, has given us what has been called the Contact Theory of the relation of neurones. This theory, which, when coupled with du Bois-Reymond's hypothesis of a neuropile capable of movement, has been eagerly followed up by many psychologists, is generally supposed to be an essential part of the neurone theory itself; but, though it was undoubtedly so regarded by its earlier advocates, it must be borne in mind that it is in reality not a necessary part of this idea, which has to do with the conception of the neurone unit as a cell rather than with the mutual relations of such units.

The discussion has now led us to a position where a fairly full statement of the grounds for the neurone theory may be

made. First, embryology has shown that the nervous system in the beginning is a mass of essentially independent cells, some of which by throwing out processes to form nerve fibres and by other modifications become converted into specially differentiated nervous cells, or neurones. Secondly, the cellular character of each neurone is asserted in later life in that all parts of the neurone remain dependent upon their connection with the nucleus for continued existence and are independent of adjoining neurones. This is seen in the peculiarities of the degeneration and regeneration of nerve, operations that are paralleled in experiments on protozoan cells.

Notwithstanding the obviousness of the cellular nature of the neurone, it must not be forgotten that these cells are of a very exceptional character. Imagine a cell whose nucleated body, scarcely visible to the naked eye, is lodged in the spinal cord of some such animal as an elephant, and whose process, in the form of an axis cylinder as fine as gossamer, stretches from this place through meters of flesh to the animal's foot, and yet the relation of the most distant part of this process to the cell body is so subtile that, should the connection be anywhere severed, the degeneration of the disconnected part invariably follows. It is not strange that such cells as these were not clearly understood by the earlier histologists, for even now they may well excite our wonder.

The objections to the neurone theory are naturally of very recent origin. One of the first to be raised was that of the direct union of cell bodies through their coarser processes. This was found by Dogiel to occur in the ganglionic layers of the retina (Fig. 3), and similar conditions were recorded by other investigators in various nervous organs; but these instances have always proved exceptional, and, while it must be admitted that nervous cells are sometimes united directly, such

FIG. 3. — Two ganglion cells from the vertebrate retina showing protoplasmic anastomoses (slightly modified from Dogiel).

cases seem to be relatively rare. So far as their bearing on the neurone theory is concerned, I agree with Barker that they form no greater objection to the general theory than the occurrence of Siamese twins does to the general idea that the human species is represented by separate individuals. This form of objection has certainly shown itself to be trivial.

A much more serious obstacle comes from the work associated with the name of Apáthy. This investigator has developed methods which in point of perfection exceed the Golgi

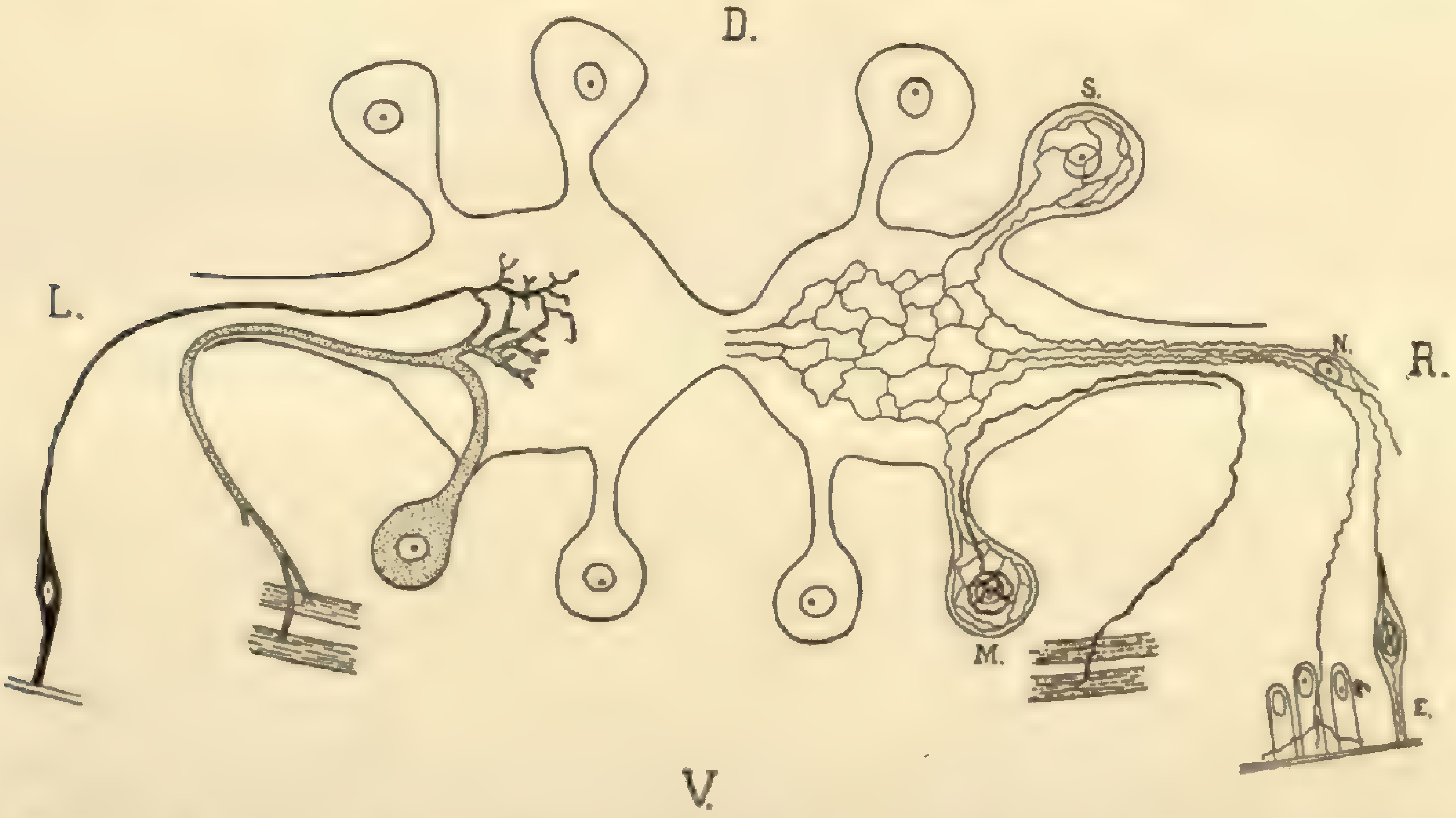

Fig. 4. — Posterior view of a transverse section of the ventral nerve chain of a leech (modified from Apáthy). The median plane of the leech is represented by *D* (dorsal), *V* (ventral). On the left side (*L*), the nervous elements are represented according to the neurone theory, a sensory neurone being represented in solid black, and a motor one dotted. On the right side (*R*) the nervous elements are represented according to Apáthy. The neurofibrils begin in or between the integumentary epithelial cells (*E*), from which they pass centrally into sensory ganglion cells (*S*) or motor ganglion cells (*M*). From the latter, coarse neurofibrils pass peripherally to muscles. The neurofibrils are produced by nerve cells, a nucleus of one of which is shown at *N*.

and the methylen-blue methods as much as these surpassed the ones before them. Apáthy's methods do not outline neurones; they differentiate the transmitting substance within the neurone. Instead of a coarse nerve fibre or ganglion cell colored homogeneously, one finds a clearly differentiated system of delicate fibrils that constitute collectively the transmitting apparatus of the nervous organs. The peculiarities of Apáthy's methods can be easily appreciated by inspecting the accompanying diagram (Fig. 4), taken from the nervous system

of the leech and outlined on the left side in accordance with the older methods and on the right after Apáthy. It will be seen at once that Apáthy's methods have to do with the interior of neurones, whereas the older methods dealt with their outlines only. When the fibrillæ so clearly demonstrated by Apáthy are traced, they are found to begin in some cases possibly between the external epithelial cells of the skin, in most cases certainly within these cells, around whose nuclei they form a network, after which they extend as bundles of fine fibrils (sensory nerve fibres) to the central nervous organs. Here they separate, and either enter into the formation of a true network (in what has been called the neuropile) or pass at once into a ganglion cell, in the substance of which they form a network. Ganglion cells of this structure are supposed to be sensory (Fig. 4, *S*). Motor ganglion cells (*M*) are also penetrated by the fibrils from sense organs, which then form a branching system just within the periphery of the cell. From this peripheral system (external plexus) branches extend inward to unite around the nucleus in a second system (internal plexus), from which a single large fibril emerges to make its way eventually as the transmitting organ of a motor fibre to a muscle into whose fibres it may enter after branching. These fibrils are the transmitting organs of the nervous system and are called by Apáthy "neuro-fibrils"; and what is most characteristic about them is that, from their beginnings in or about the sensory cells to their endings in the muscles, they are absolutely continuous; they branch and recombine, but they never show lack of continuity; and this continuity of the fibrillar substance is the feature that characterizes what has been called the fibrillar theory — the supposed opponent of the neurone theory.

Apáthy's opposition to the neurone theory does not stop here, for he has a conception of the structure of the nervous system quite at variance with the tenets of this theory. He holds that the cells connected with nervous operations are of two kinds, which he calls nerve cells and ganglion cells. Nerve cells are those cells that produce fibrillar substance, and this substance in its growth enters sensory cells, ganglion cells, muscle cells, etc.; in short, it is the means of binding the whole nervous

system together. Ganglion cells are those cells that produce what is transmitted by the fibrillar substance, namely, nervous impulses.

So far as I am aware, Apáthy has never placed upon record the observations that justify these distinctions, and, as criticism and acceptance of his unsupported statements are equally premature, it seems to me that, till facts are presented, this side of his work must be passed over. If this is done, the character of the fibrillar substance is the only feature of Apáthy's work that requires present consideration. The distribution of this substance is for the most part within neurones. Hence Apáthy's discoveries have to do mostly with the internal anatomy of the neurone, and from this standpoint they afford no ground for attacking the neurone theory. In one respect, however, they bear in an important way on this theory, namely, in the structure they indicate for the neuropile. Is the neuropile a continuous network made up of the anastomoses of neurofibrils, as claimed by Apáthy, or does it lack this continuity in that it is composed of systems of branches derived each from a separate neurone and related only through contact, as implied by the neurone theory?

Apáthy's figures and statements favor in an unqualified way the idea of continuity, but the solution of this problem, one of the most difficult in modern histology, is to be accomplished only by the aid of many hands. It is, therefore, gratifying to find that Bethe has devoted no small amount of time to a critical study of Apáthy's methods and results. Bethe has confirmed many important statements made by Apáthy, but he has been unable to find reasons for accepting Apáthy's distinction of ganglion and nerve cells, and he has shown that Apáthy's generalization of motor fibres, being characterized by one coarse fibril, and sensory fibres by many small ones, does not hold true for the arthropods. He has, however, confirmed the principal statements of Apáthy as to the presence of neurofibrils in nerve fibres and in cells; and, on the important question of the nature of the neuropile, Bethe agrees in his conclusions with Apáthy in stating that it is a continuous network. When, however, the facts for this conclusion are sought for in the

body of Bethe's paper, they are found to be not very convincing. In his third study[1] on the central nervous system of the crab (Carcinus), he discusses the question of fibrillar continuity in the neuropile and states that in this animal he has never been able to discover continuity between the fibrils of two neurones, though he has some evidence from the leech that he believes supports this idea and that he proposes to publish later. Such a statement of lack of conclusive evidence on an all-important point can scarcely be called a confirmation of the idea of continuity.

These seem to me the most important contributions made against the neurone theory, and I believe it must be admitted they are not fatal objections. In no case has any one made observations which show that each neurone does not begin as an essentially independent cell, suffering eventually remarkable modifications, but still retaining its character as a single cell. In no case has any one shown that the individuality of the adult neurone, as seen in the degeneration and regeneration of its parts, has suffered any reduction as compared with that of the simple cell from which it came. It seems to me, therefore, that the neurone theory is still intact, and that what has been shown by this new work is that the interior of a neurone has a most delicate and complicated fibrillar structure, which possibly is a means of welding together adult neurones much more closely than has been generally admitted. But of this we have as yet no adequate proof.

[1] Bethe, Albrecht. Das Centralnervensystem von Carcinus Maenas. Ein anatomisch-physiologisch Versuch. II. Theil. (3. Mittheilung). *Archiv für mikroscop. Anat.* Bd. li, pp. 382–452, Taf. XVI–XVII. 1898.

VARIATION IN THE VENATION OF TRIMEROTROPIS.

JEROME McNEIL.

A RECENT study of nearly all the known species (fifty out of fifty-four) of the orthopteran genus Trimerotropis has afforded the writer an opportunity to note the amount of variation which occurs in the venation of the tegmina and wings of a single genus. Three out of the four subfamilies of Acrididæ found in North America north of Mexico, *i.e.*, Acridinæ, Tryxalinæ, and Œdipodinæ, present but a single and little modified type of venation well represented by the *Tr. vinculata* Scud (Figs. 1, 2).

The remaining subfamily, Tettiginæ, is so extremely different as to show little relationship to Acrididæ. In all the drawings the terminology used is that of Comstock and Needham, with the very slight modifications necessary to adapt it to Orthoptera. The homologies have been determined by the writer from a study of the tracheation of the tegmina and wings of nymphs, which is to be published shortly.

It will be noticed by those familiar with this nomenclature that the branches of *R.* have been named as if they were accessory branches entirely, whereas it is very probable that some of them represent the primary forks of that vein. At present it is impossible to be quite certain of these homologies, so that the simplest way of naming them has been employed without claiming for it complete accuracy.

Variations within a Species.

For the purpose of studying the variation within the limits of a single species I have selected *Tr. saxatilis* McN., a species from Arkansas and southern Illinois, and one of the three species known to occur east of the Mississippi. This form was not selected because of its being unusually variable in venation,

but because I had a larger number of specimens (fifty-seven) of this than of any other species, and these were all collected during the same season in four or five counties of northwest Arkansas, except three, which came from Union County, Illinois. At the same time it is well to note that it is more variable in color than any other species known to me. It frequents stony surfaces exclusively, and its colors vary with the colors of the stones. On black rocks it is nearly black in color, while on

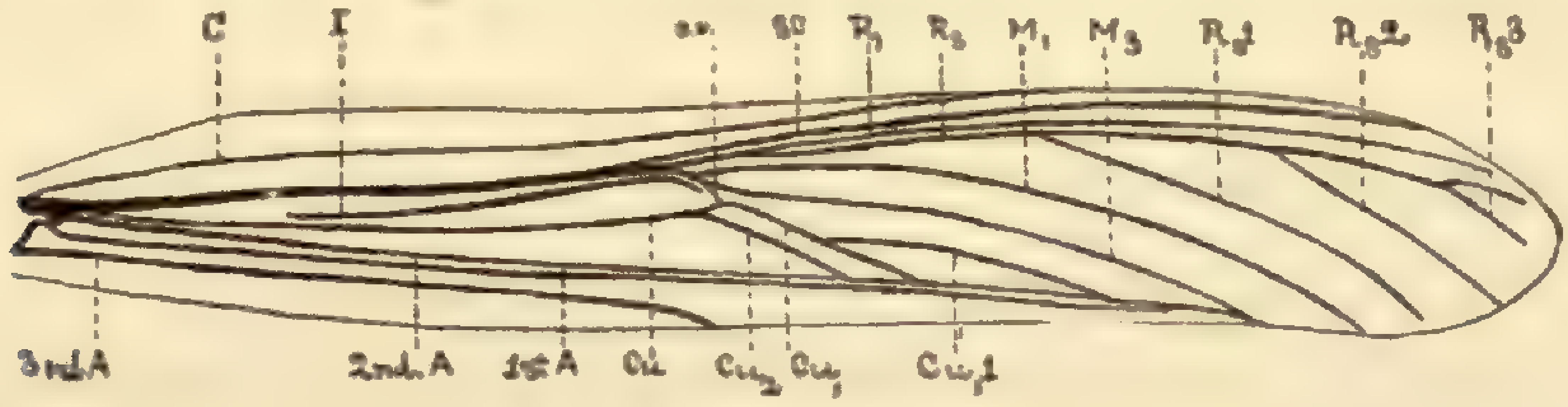

FIG. 1.

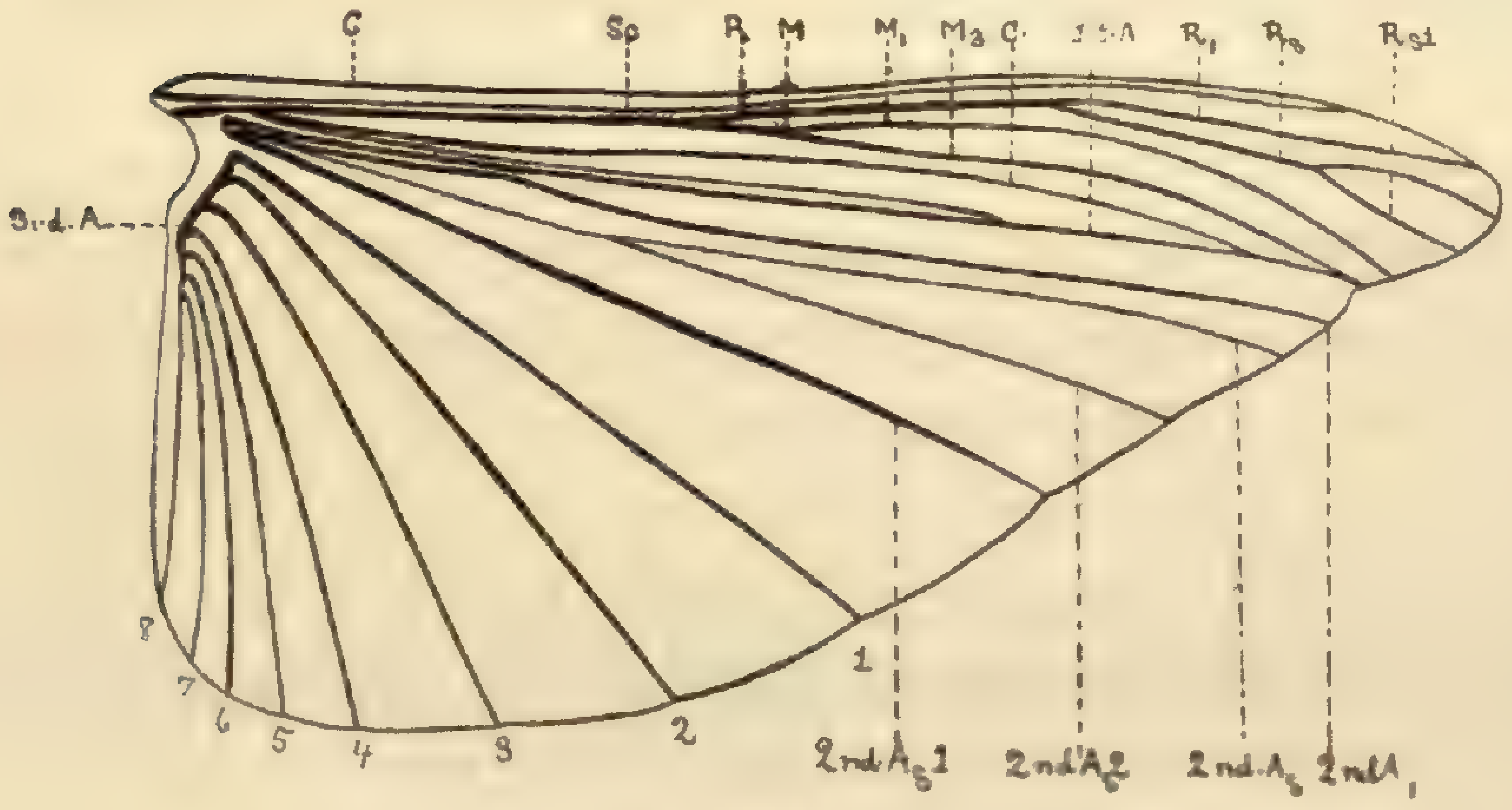

FIG. 2.

C., costa; *Sc.*, subcosta; *R.*, radius; *R.*1, first fork of radius; *R.*s, radial sector; *R.*s *1, 2*, etc., 1st, 2d, etc., branches of *R.*s; *M.*, media; *M.*1, first and second forks of *M.* fused; *M.*3, third and fourth forks of *M.* fused; *I.*, intercalary; *c.v.*, cross-vein at end of area *M.*; *Cu.*, cubitus; *Cu.*1, first fork of cubitus; *Cu.*2, second fork of cubitus; *Cu.*1 *1, 2*, first and second forks of *C.*1; *Cu.*2, *1*, first fork of *C.*2; *1st A.*, first anal vein; *2nd A.*, second anal vein; *2nd A.*1, first fork of *2nd A.*; *2nd A.*s, sector of *2nd A.*; *2nd A.*s *1, 2*, first and second forks of the sector of the second anal vein; *3rd A.*, third anal vein; *3rd A.*, *1–8*, accessory branches of *3rd A.*

The tegmina and wings are divided by the principal veins and their branches into areas which take the name of the vein or branch immediately anterior.

hillsides covered with black and white lichen-covered fragments of chert it is colored black, white, and green, so that away from its environment it is a very conspicuously colored insect. It will require, however, more extended observations than I have been able to make to know whether or not there is any relation between variation in coloration and venation.

In the tegmina *C.* and *Sc.* are simple veins which do not vary in such a manner as to be readily noted; the former is about halfway between the anterior margin and the three succeeding veins, which are so closely approximate on the proximal half of the tegmina as to appear one vein to the unaided eye. *R.* is quite variable, though $R._{1}$ does not share in this variation. $R._{s}$ has normally three branches in the male and four in the female, but of the fifty-seven specimens examined six males have four branches and one male has two, and eight

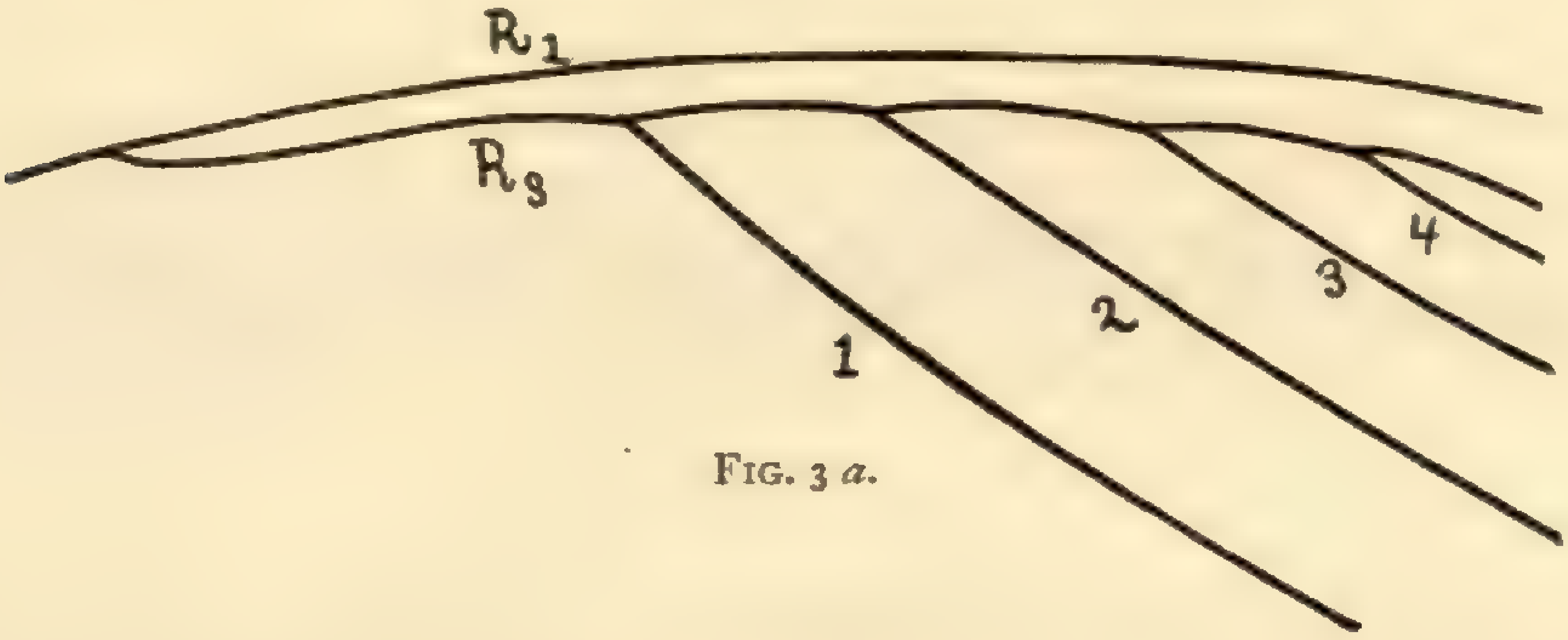

Fig. 3 *a*.

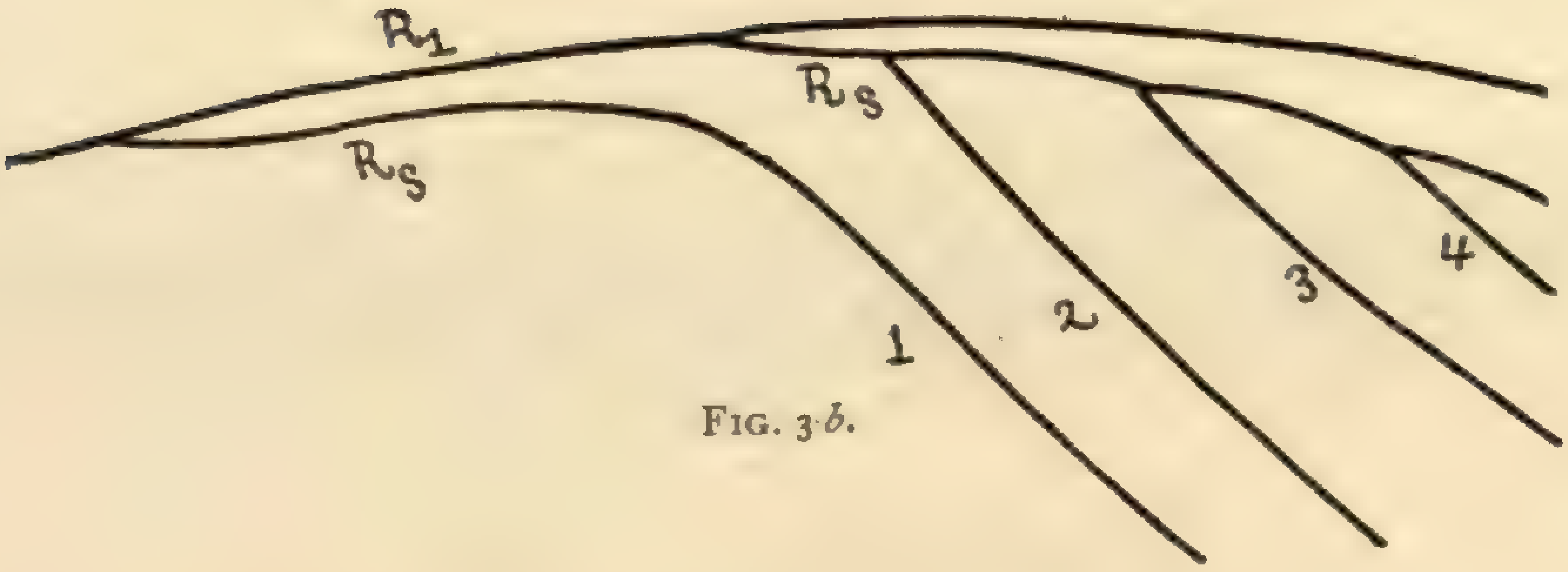

Fig. 3 *b*.

females have three branches; thus about 24 per cent show irregularity in this respect. Within the genus the variation which normally occurs in the number of branches of *R.* is exactly the same; within the subfamily the range is considerably greater, being but one in Celes and six in Pachytylus, both old-world genera. In a single instance the apical part of $R._{s}$ with two branches has lost its connection with the basal part with one branch, and the former is separately connected to $R._{1}$ (Figs. 3 *a*, 3 *b*).

No similar variation is normal in the genus nor within the subfamily, so far as I know. The second branch of $R._{s}$ may

lose its connection with $R._s$ and become attached to the first branch (Figs. 4 *a*, 4 *b*).

This arrangement is abnormal in the genus and probably in the subfamily, and occurs but once in the fifty-seven speci-

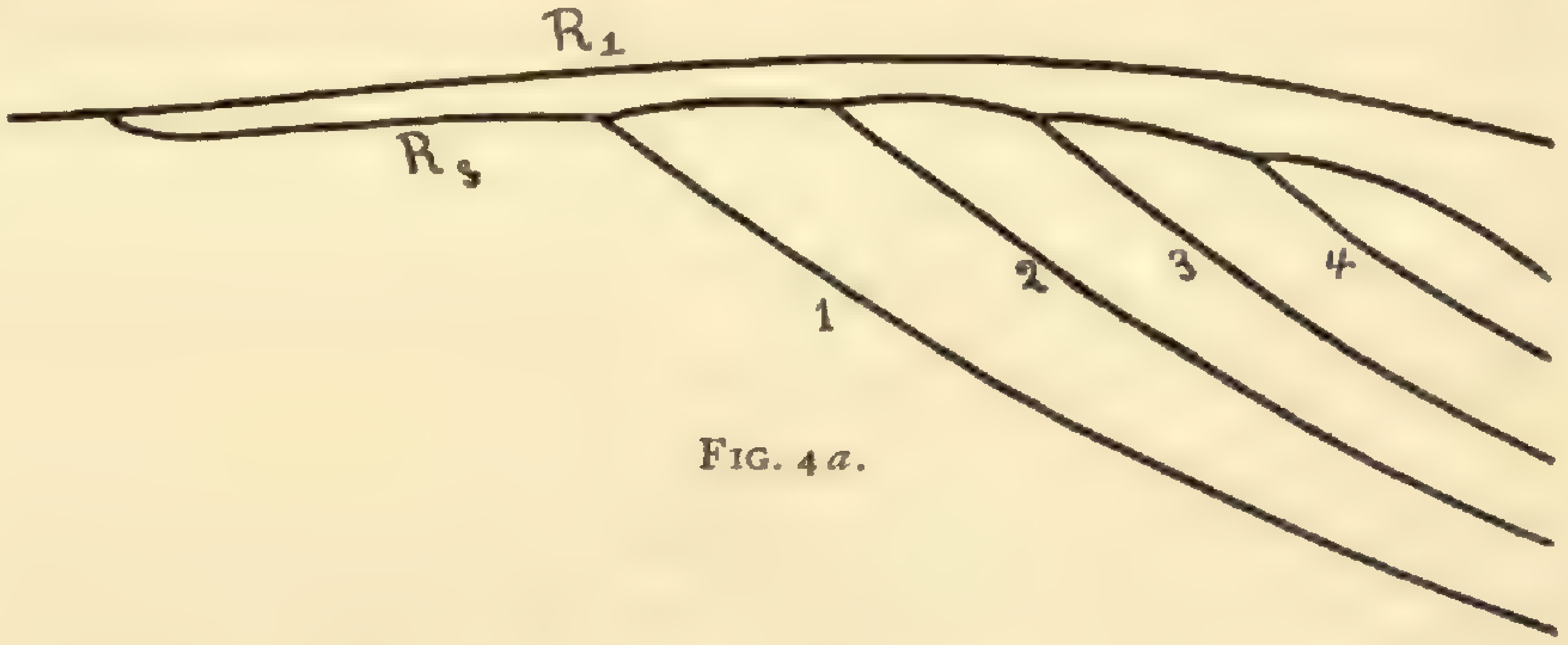

Fig. 4 *a*.

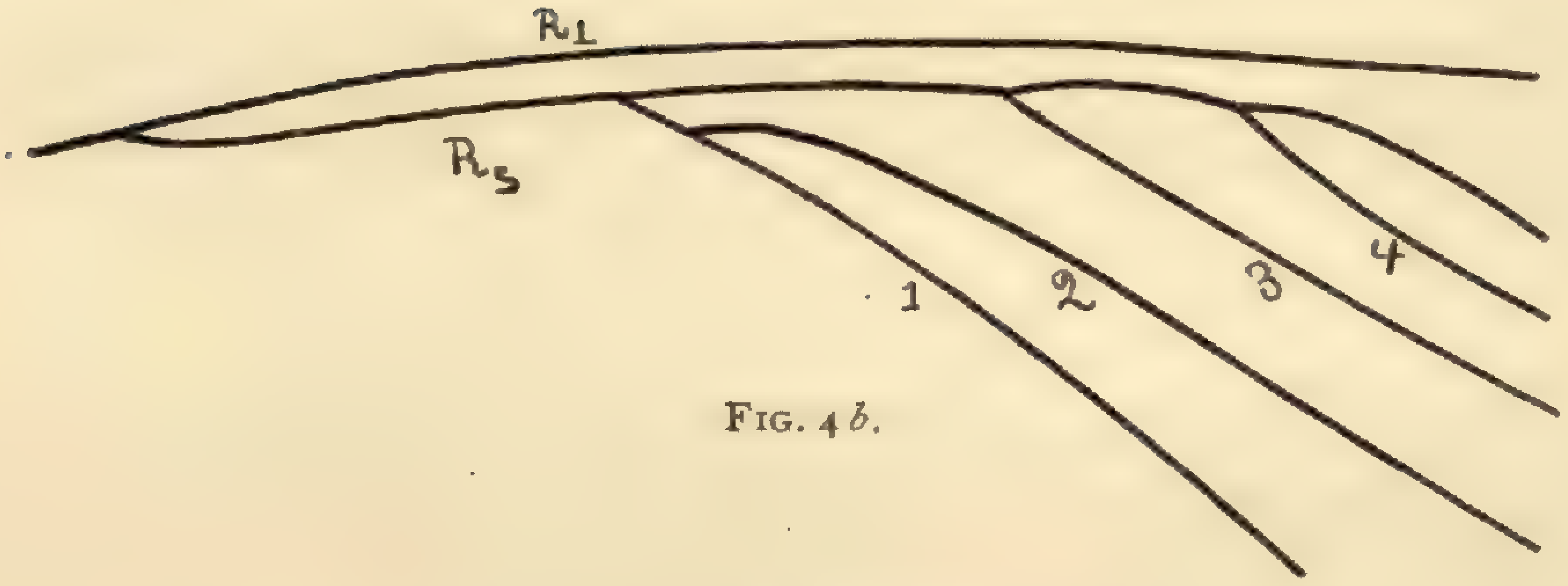

Fig. 4 *b*.

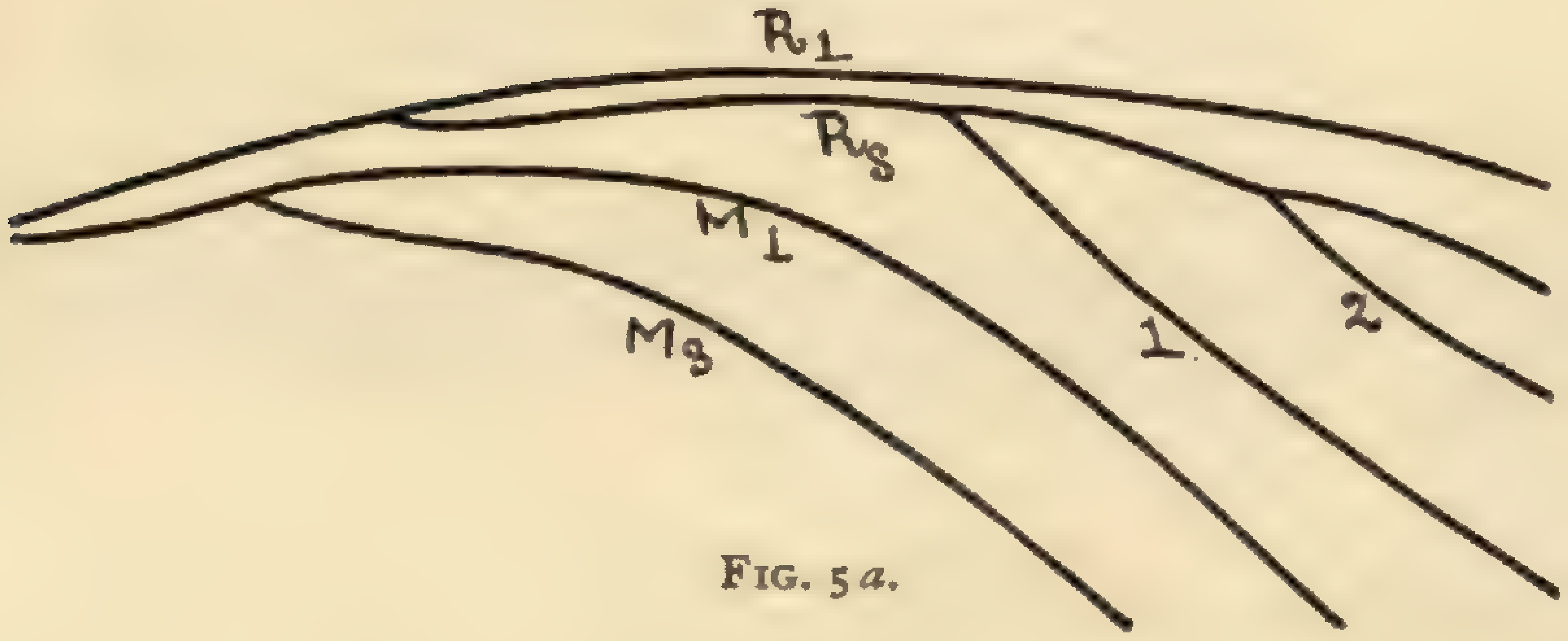

Fig. 5 *a*.

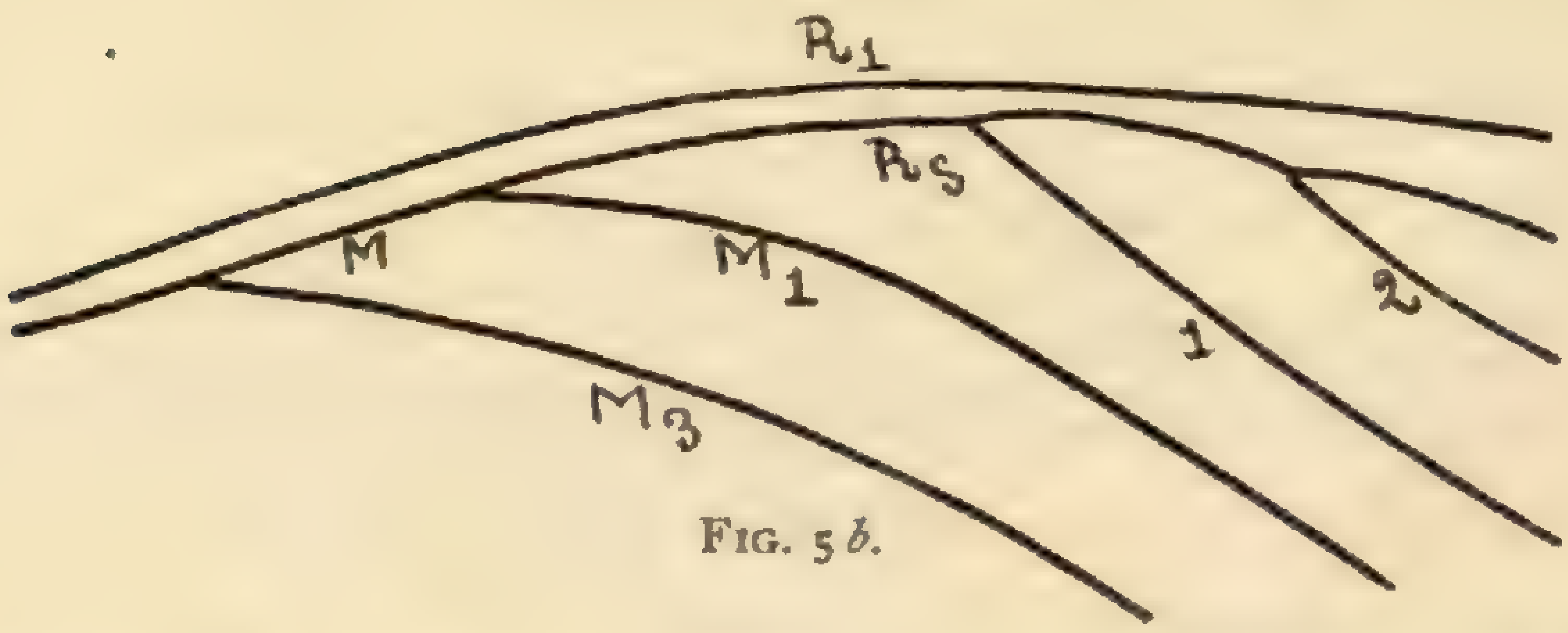

Fig. 5 *b*.

mens; but in this case the irregularity is present in both tegmina. In a single instance, also, the third branch in one tegmen forks. Finally, in three specimens, two males and one female, $R._s$ leaves $R._1$ and becomes attached to $M._1$ (Figs. 5 *a*, 5 *b*).

This occurrence is common in *Psinidia eucciata,* if it is not the rule, and it seems to be natural to Œdaleus. The fork of *R.* is quite variable in position. Generally it is one-third the width of the tegmina at this point distad of *M.* fork, but in three cases it is more than one-half, while in one instance it is more than once, and in another one-eighth, the width of the

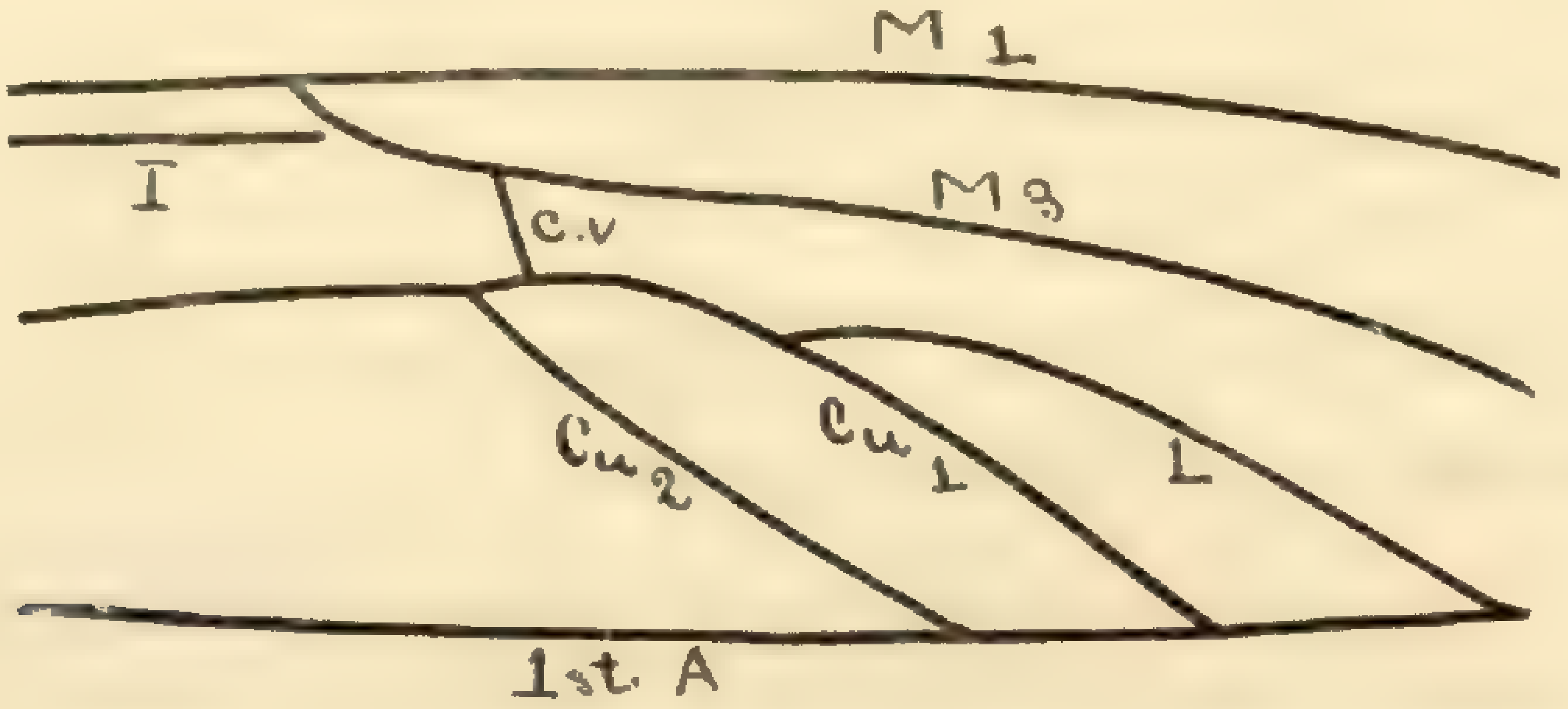

Fig. 6 *a*.

tegmina distad of the same point. This is certainly equal to any similar variation normal to the genus and is rarely exceeded in genera of the subfamily. *M.* has two simple forks, $M._1$ and $M._3$, which do not vary conspicuously. The fork of *M.*, however, which is usually decidedly proximad of the fork of *Cu.*, in four females and two males, is parallel with it or even slightly distad. In a single instance the cross-vein, which is always

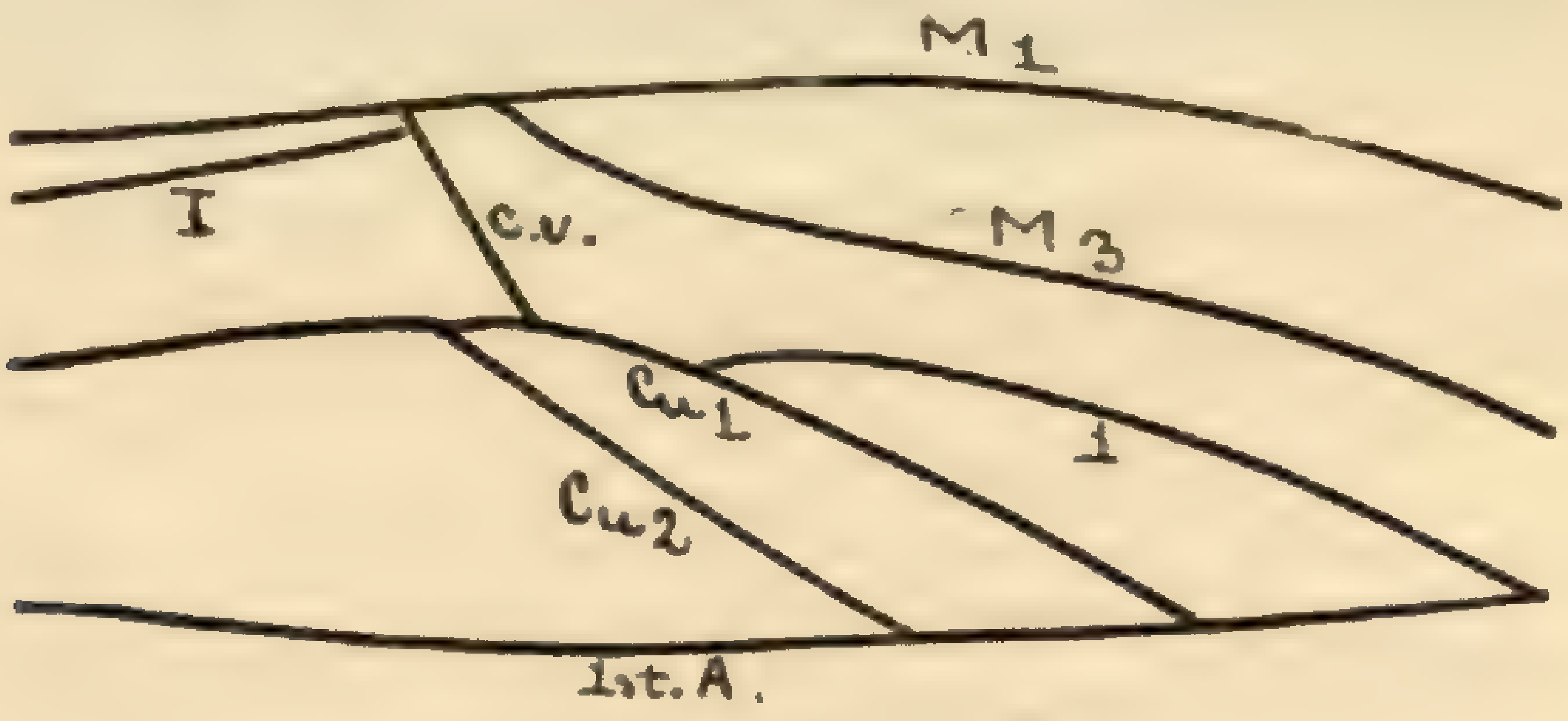

Fig. 6 *b*.

present at the outer end of area *M.*, and which usually, in the genus as well as in the subfamily, when present, connects $M._3$ and $Cu._1$, joins the main stem of *M.* with $Cu._1$ (Figs. 6 *a*, 6 *b*).

The intercalary vein, which is usually separated apically from *M.* by once, male, or two or more times, female, its width, has this relation reversed in a single female and seven males.

In one specimen *M.*$_3$ loses its connection with *M.*$_1$ and appears to be a continuation of *I.* (Figs. 7 *a*, 7 *b*).

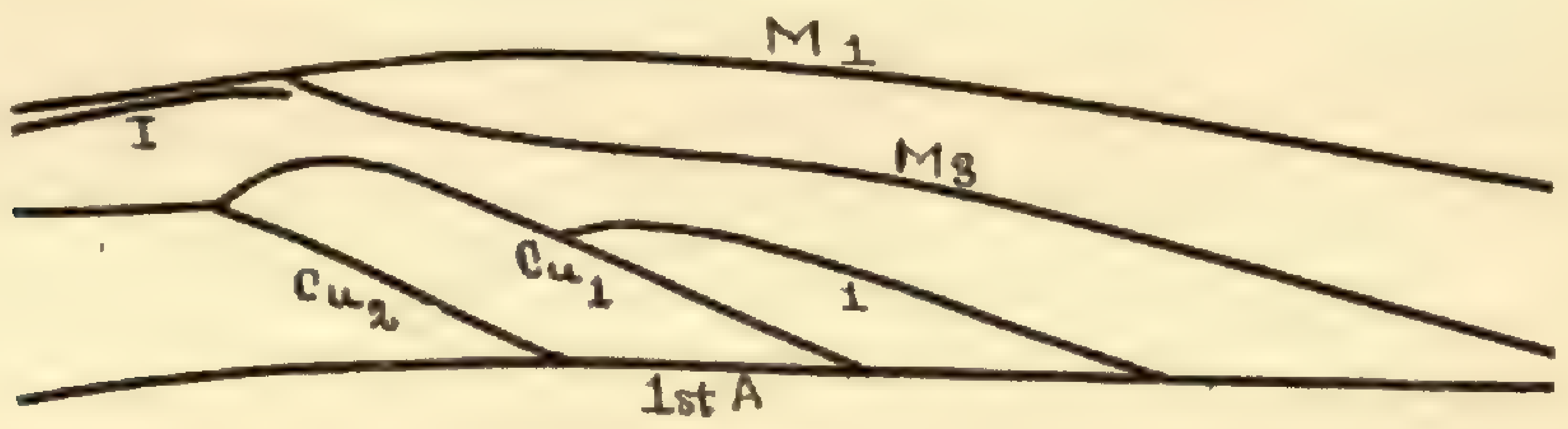

FIG. 7 *a*.

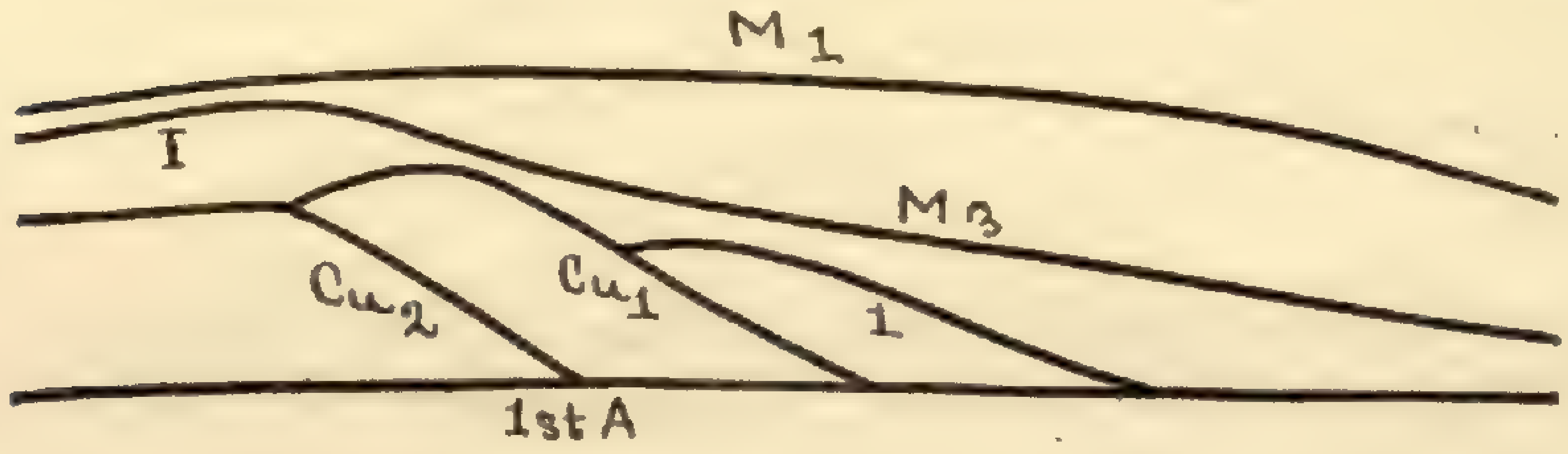

FIG. 7 *b*.

Cu. is quite variable, typically; *Cu.*$_1$ has a single anterior branch which leaves the stem near the base, but in one specimen this branch is joined to *Cu.*$_1$ below its middle, and in one case there are two branches on one side. In the genus there

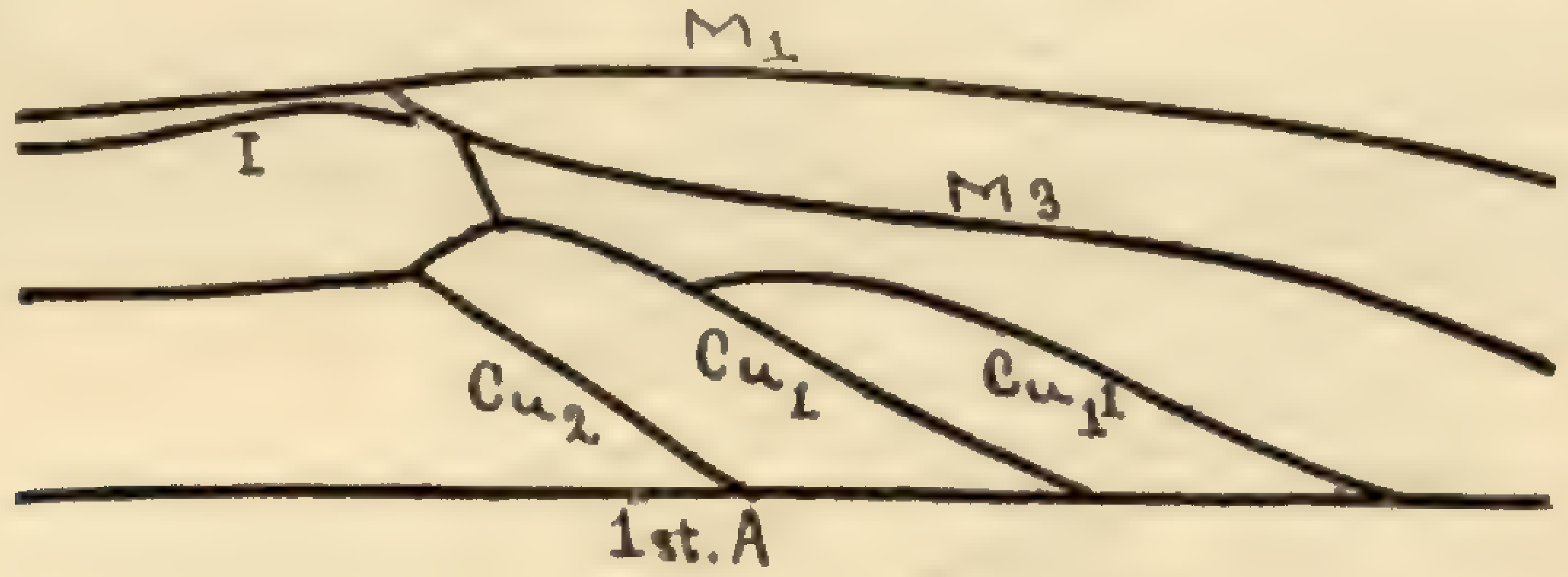

FIG. 8 *a*.

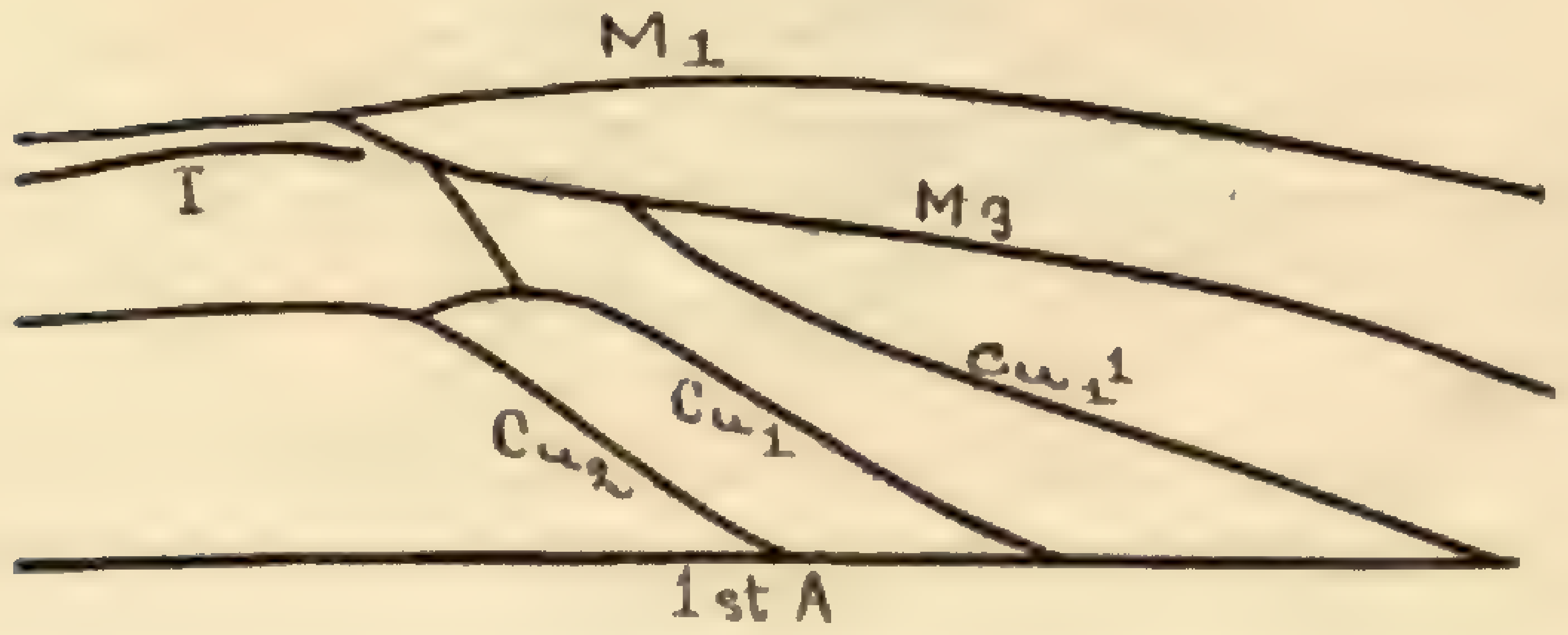

FIG. 8 *b*.

are never fewer than one, nor more than two, branches normally. In one female in one tegmen the branch of *Cu.*$_1$ is transferred to *M.*$_3$ (Figs. 8 *a*, 8 *b*).

1st A. and *2nd A.* are simple veins, whose variations are not easily noted; but *3rd A.*, while usually simple and free to the posterior margin or with its apex lost among the numerous cross-veins of the anal area, is definitely connected apically with *2nd A.* in four males and two females. In all cases except one this fusion is common to the two tegmina. This is the rule in Chortophaga.

In the Wing.

As in the tegmina, *C.* and *Sc.* are simple and vary little; the former occupies the costal margin; the latter is approximate to, or fused with, *C.* on the distal one-half or one-third of the wing; $R._1$ remains simple. $R._s$ varies greatly, while it generally has one branch; in five males and one female it has none,

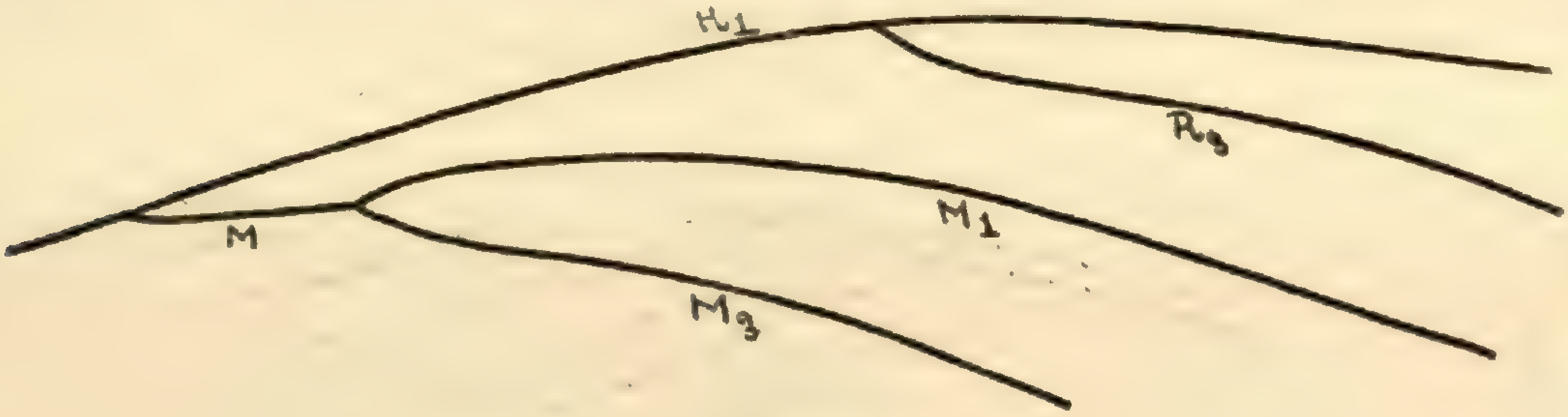

FIG. 9*a*.

and this is the usual condition in Encoptotaphus, Chortophaga, and Derotmema. This branch of $R._s$ varies from less than one-fourth the length of $R._s$ in two males and one female to more than one-half in five males and four females; when normally developed it is about one-third. *R.* fork should be halfway

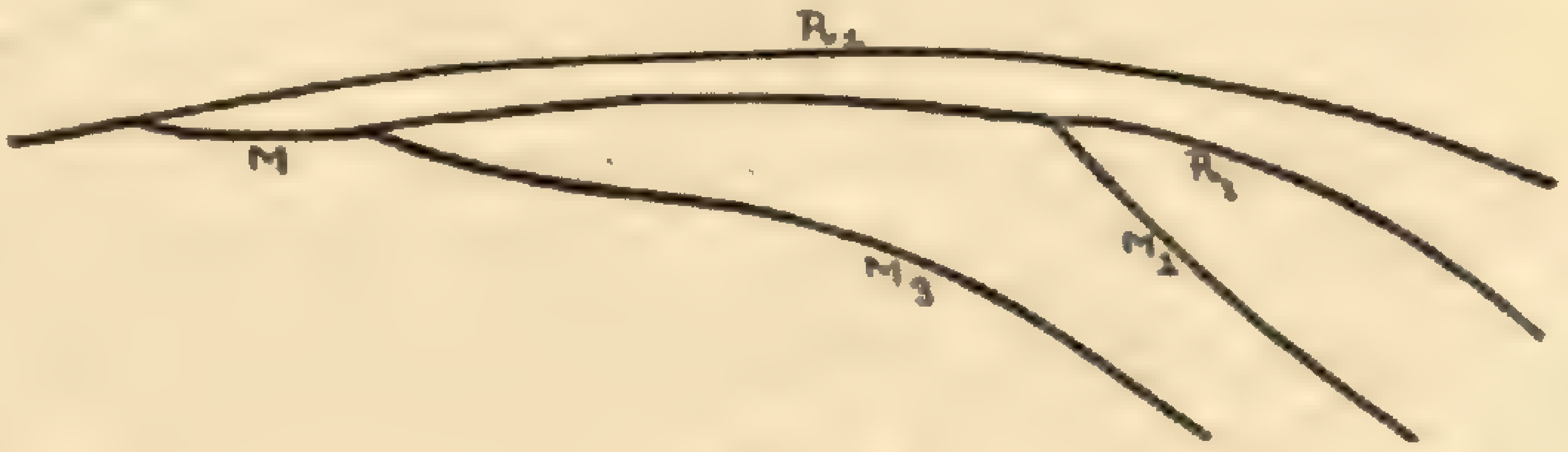

FIG. 9*b*.

from the union of *M.* and *R.* to the tip of the wing. In numerous specimens it is a little more, and in two males and two females less, than one-third of the way. In two males $R._s$ has no branch and is connected with $M._1$ instead of $R._1$ (Figs. 9 *a*, 9 *b*).

The union of *R.*$_s$ with *M.*$_1$ in the wing is characteristic of the genus Dissosteira (except *D. venusta* Stal). *M.* is also quite variable. Its forks are always simple, but in four males they join *R.* separately (Figs. 10 *a*, 10 *b*).

Usually, the stem of *M.* before it branches is rather more than the width of the area *M.*; but in five males and two females it is less than once as wide, in this respect resembling

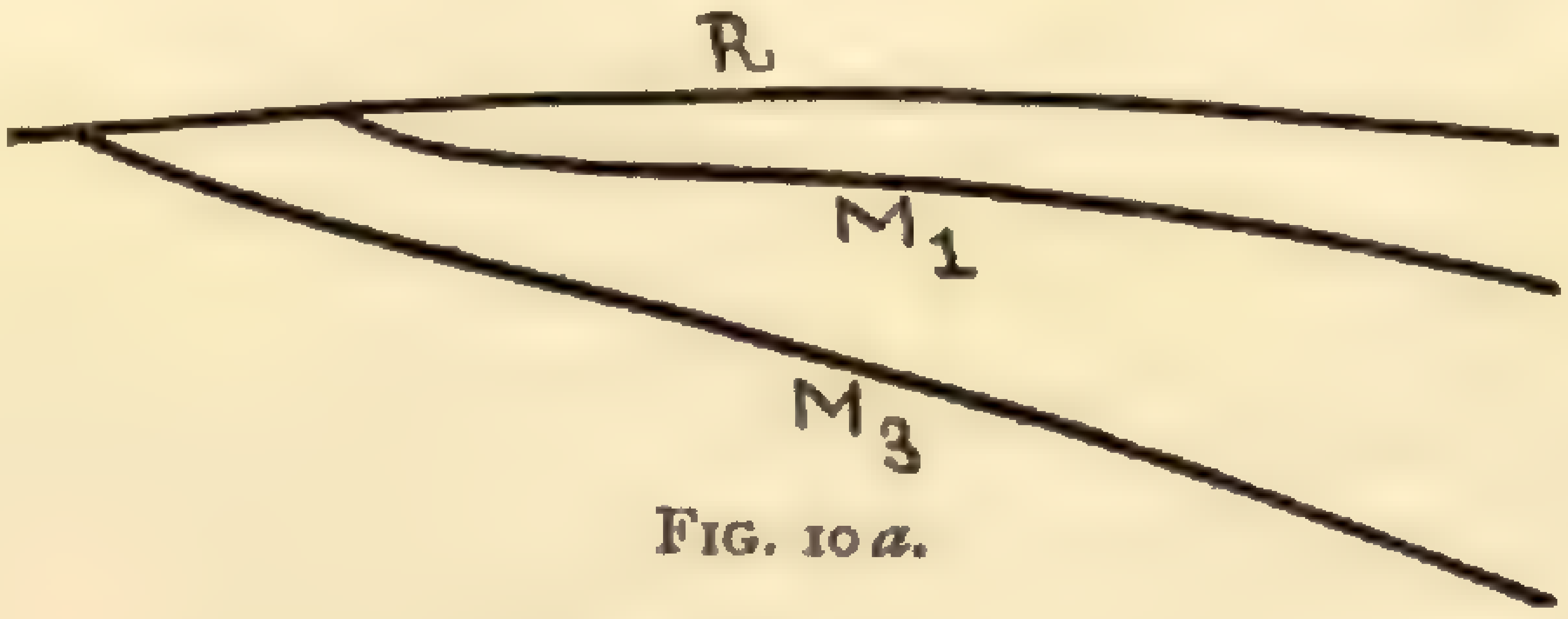

FIG. 10 *a*.

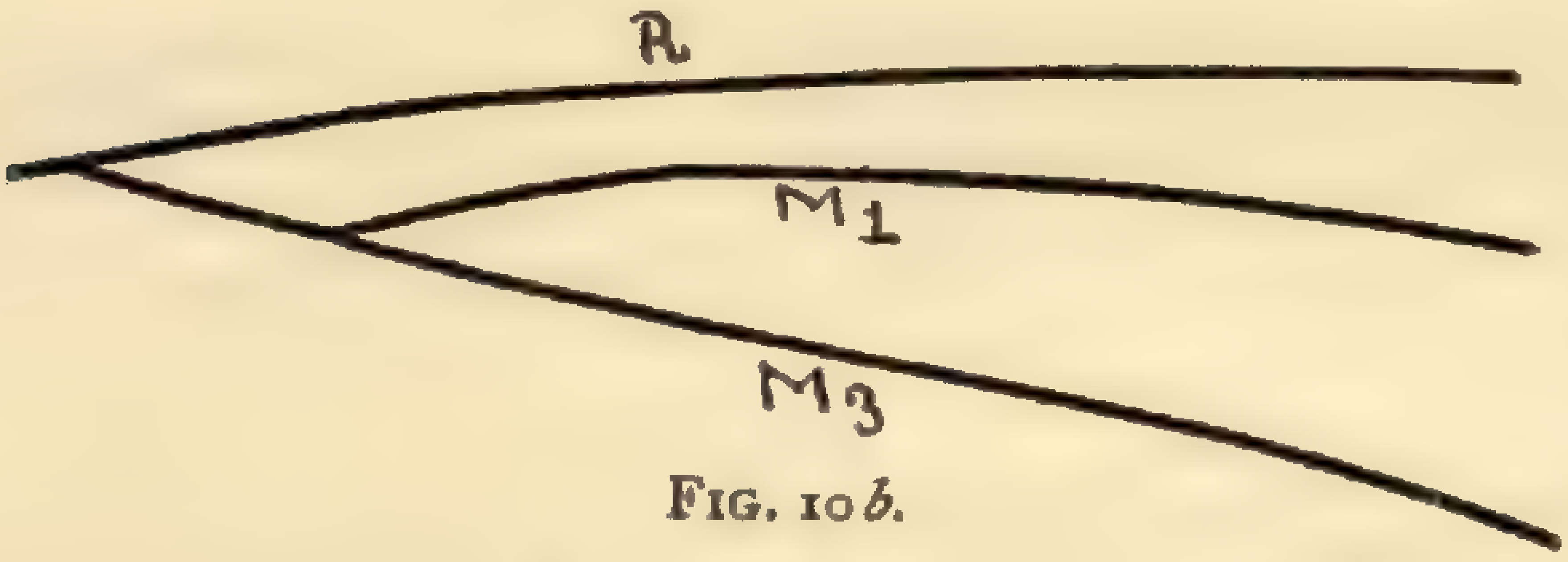

FIG. 10 *b*.

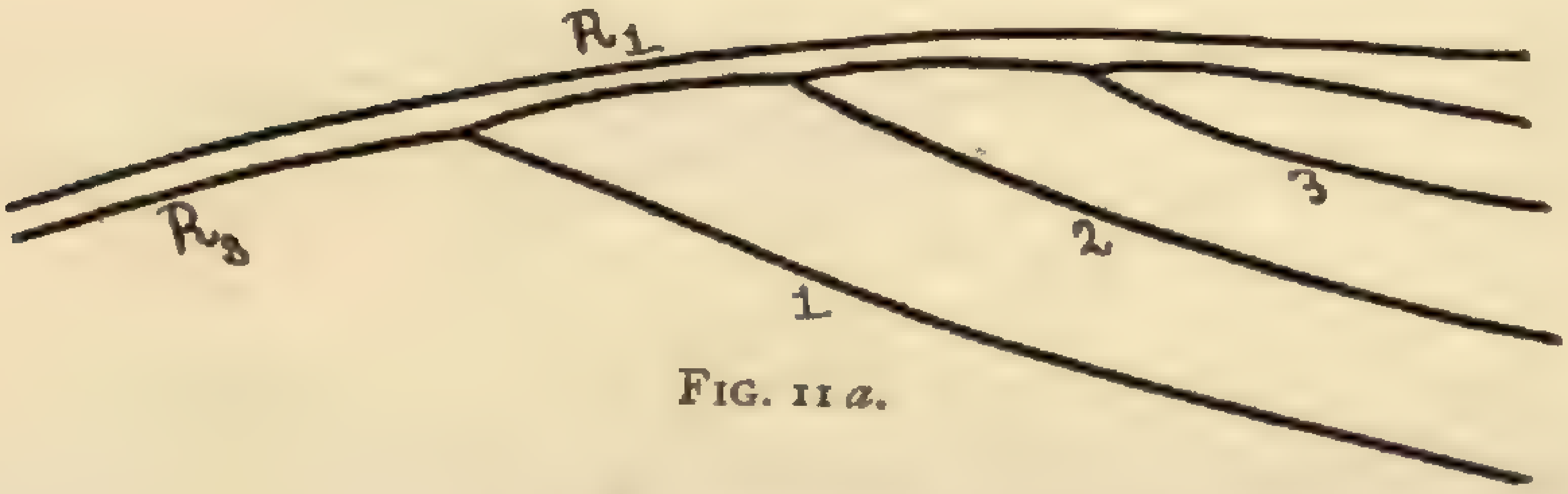

FIG. 11 *a*.

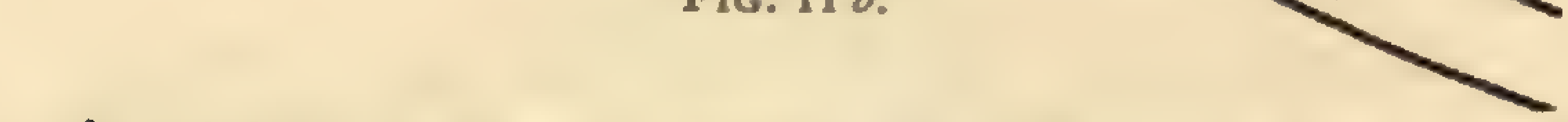

FIG. 11 *b*.

the genus Arphia; and in seven males and five females it is more than twice as wide, which is the usual condition in the genus Hippiscus. *Cu. 1st A.*, *2nd A.*$_1$, and *2nd A.*$_s$ offer no easily noted variations; but the union of *2nd A.*$_s$ *2* with *2nd A.*$_s$ may be, apparently, distant from the base as much as two-fifths, or as little as one-fourth, the length of the latter. When the distance is less than two-fifths, however, a diagonal cross-vein at this point indicates the normal connection of the vein and its branch.

In conclusion it may be said that the variations in the tegmina and wings of one side average nearly two in the females and rather more than two in the males, as variations on one side are generally repeated upon the other; the average num-

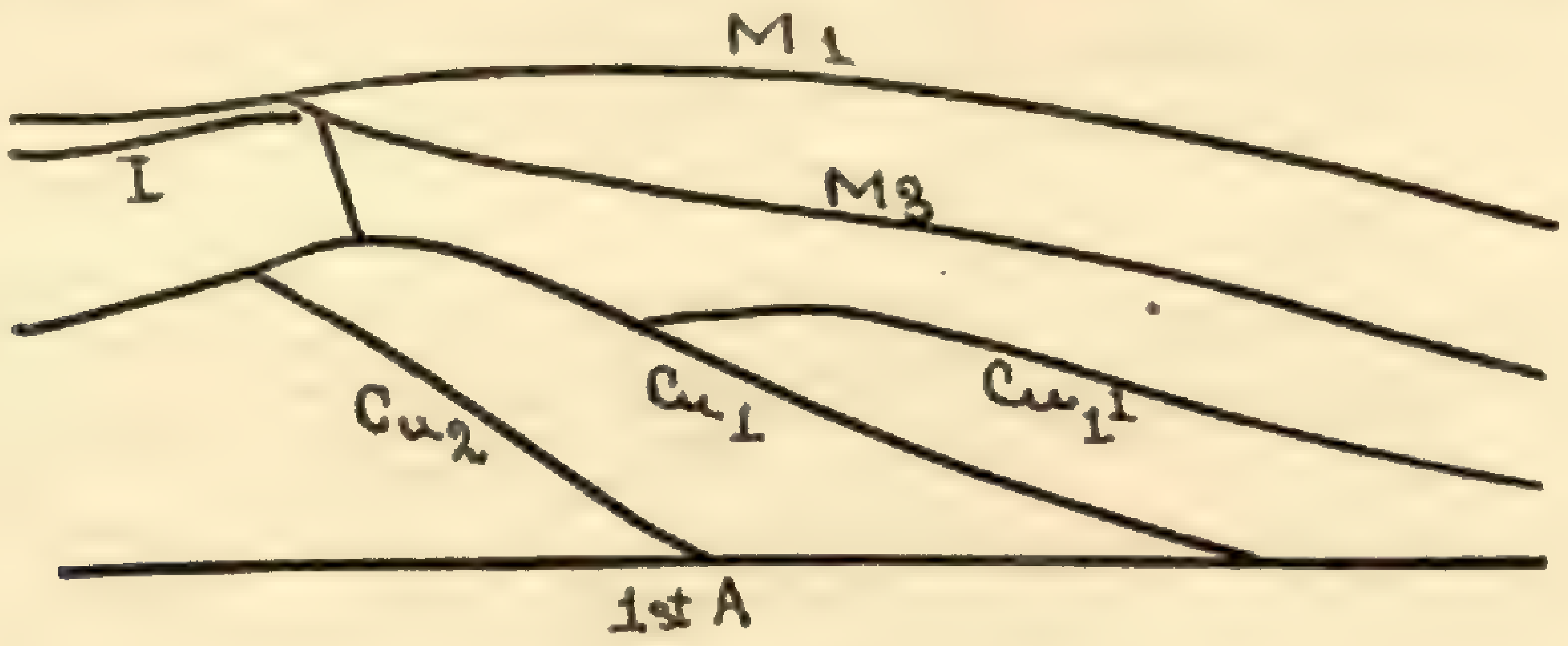

Fig. 12 *a*.

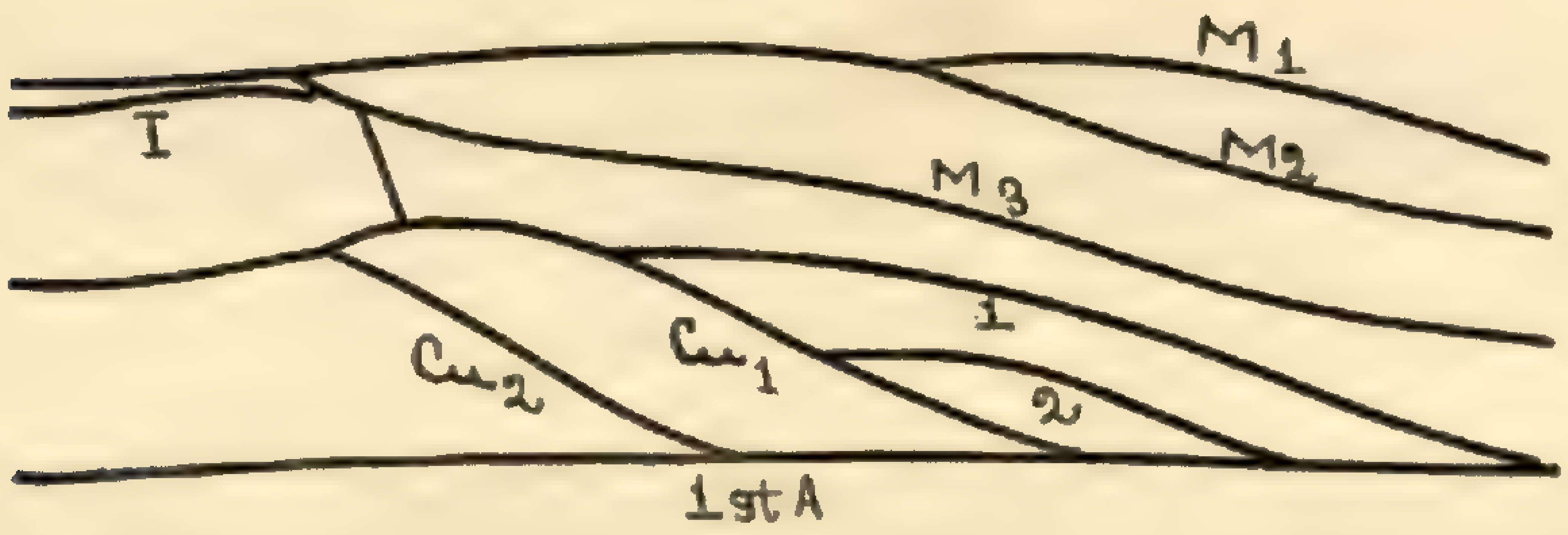

Fig. 12 *b*.

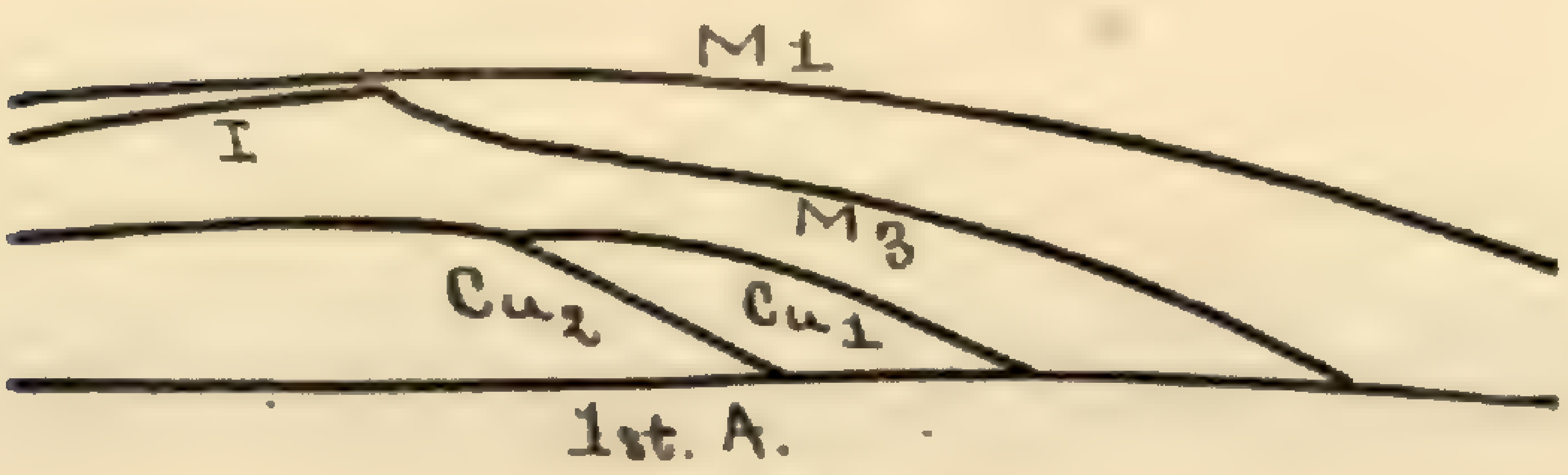

Fig. 13 *a*.

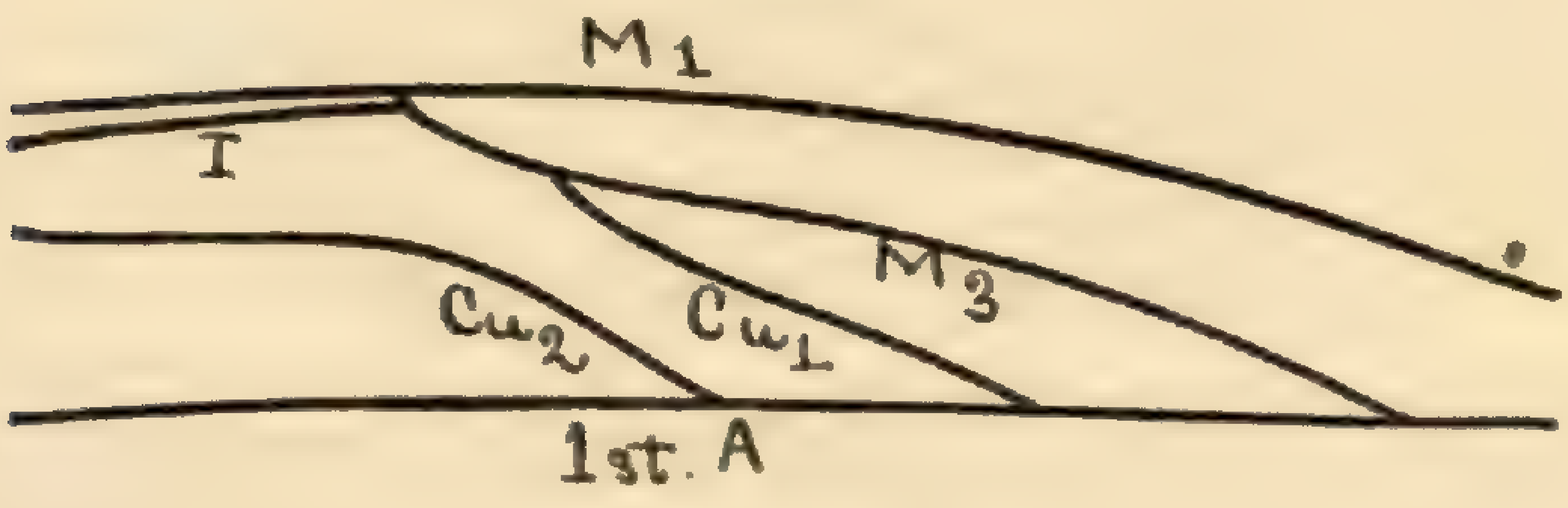

Fig. 13 *b*.

ber on both sides would be not much less than four. There were almost exactly three variations in the tegmina to two in the wings.

Variations within the Genus.

In addition to the variations which have already been mentioned as occurring in *Tr. soxatilis* the following have been

noticed, one or more times, in other species of the genus. In *Tr. lanta* the second and third branches of $R._s$ have a common stem (Figs. 11 *a*, 11 *b*).

In *Tr. azurescens*, $M._1$ may fork (Figs. 12 *a*, 12 *b*).

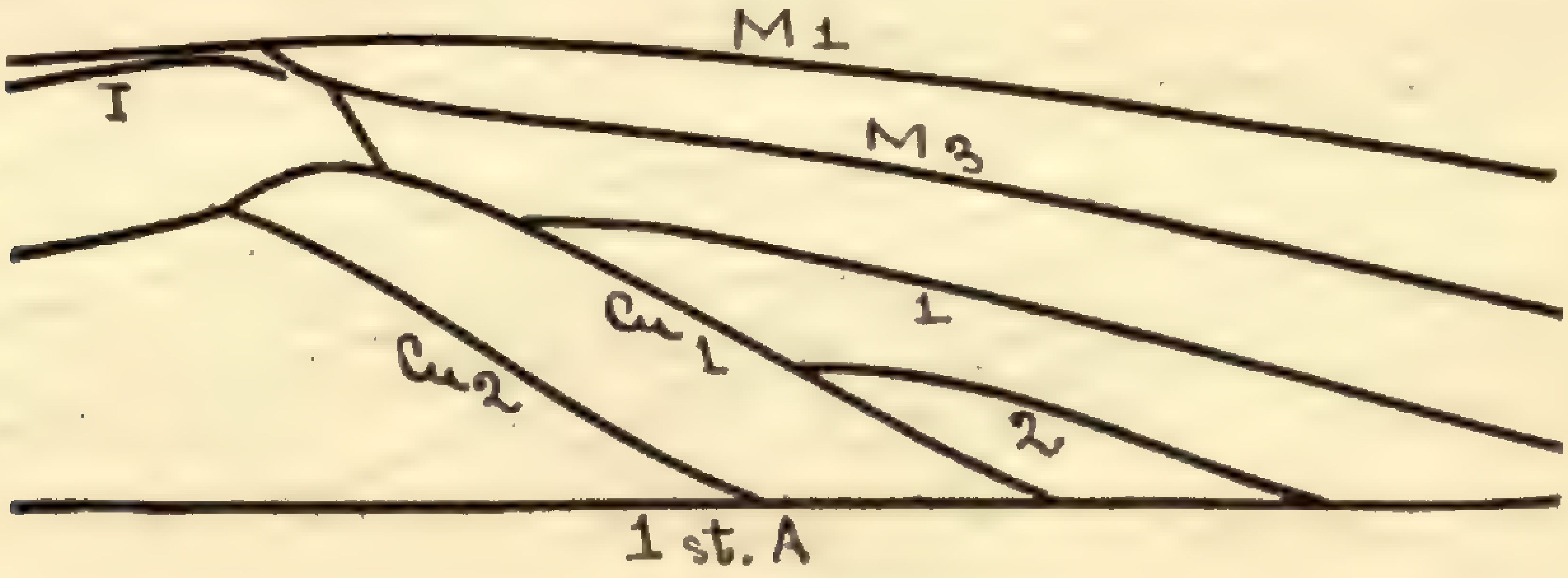

FIG. 14*a*.

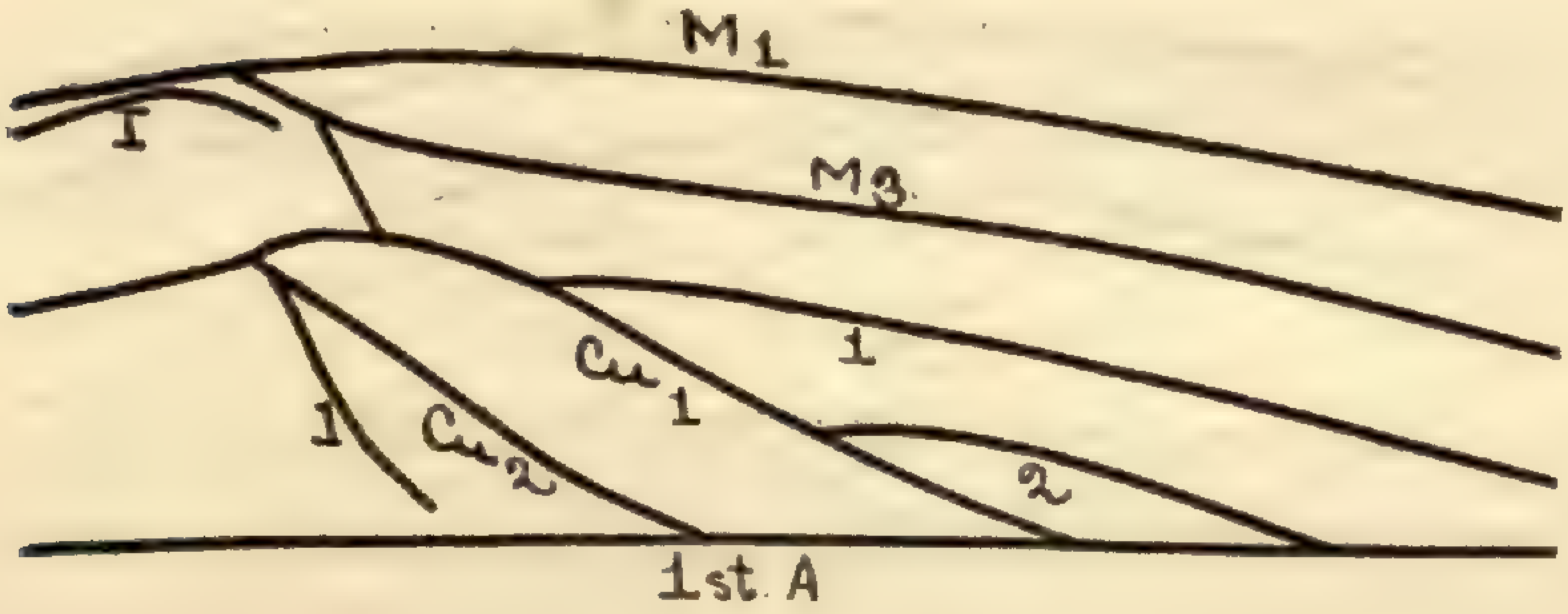

FIG. 14*b*.

In *Tr. albolineata*, Cu_1. loses its connection with $Cu._2$ and becomes attached to $M._3$ (Figs. 13 *a*, 13 *b*).

Unless the tegmina figured by Saussure[1] is abnormal, this is the usual condition in the genus Scintharista. In the species *Tr. vinculata*, $Cu._2$ may be branched (Figs. 14 *a*, 14 *b*).

GENERAL CONCLUSIONS.

1. Variations in venation which occur within a single species are much greater than those differences which distinguish one genus from another. That is to say that many of the variations which occur are not restricted to what are commonly considered specific limits, but are such as are paralleled only in widely separated genera of the subfamily, and some of them do not normally occur within the limits of the subfamily.

2. Variations in venation which occur in the various species

[1] Saussure, H. de. *Prodromus Œdipodionum*, Pl., Fig. 10. Geneva, 1884.

of the genus merely serve to strengthen the conclusion just formulated, and, except in the number of branches of radius in the tegmina and wings, are greater than normally occur in the subfamily.

3. Variation affects chiefly the veins $R._s$, *M.*, and *Cu.* in the tegmina, and $R._s$ and *M.* in the wings, and these on the outer half of the wings only.

4. Variation in venation is more frequent in the tegmina than in the wings.

5. When the tegmina are widened, new veins are supplied by accessory branches of $R._s$ and $Cu._1$.

NOTES ON THE MAMMALS OF PRINCE EDWARD ISLAND.

ROBERT T. YOUNG.

THE following is an annotated list of mammals observed during a three weeks' stay in Prince Edward Island in the fall of 1897.

1. *Sciurus hudsonicus gymnicus.* — A fairly common species. My specimens agree pretty closely in size with those from New Brunswick and Nova Scotia. It is interesting to note that skins from this section average decidedly smaller than those from Ontario (Miller)[1] and Labrador (Bangs).[2] This seems rather strange, considering that in grading off into the southern form, *loquax*, it increases rather than diminishes in size. Average of six specimens from New Brunswick (American Museum of Natural History, New York): total length, 277; tail, 110; hind foot, 43. Average of ten from Digby, Nova Scotia (Bangs): total length, 296; tail, 113; hind foot, 45. Average of two from Prince Edward Island (Young): total length, 282; tail, 113; hind foot, 45. Average of four from Hamilton Inlet, Labrador (Bangs): total length, 309; tail, 120; hind foot, 48. Average of eight from Ontario (Miller): total length, 309; tail, 121; hind foot, 47. Average of eight *Sciurus h. loquax* from Liberty Hill, Connecticut (Bangs): total length, 318; tail, 134; hind foot, 47.

2. *Mus musculus.* — One specimen was caught in a bushy field, largely grown up with Juncus, near Georgetown.

3. *Peromyscus canadensis.* — Two specimens were all that I secured, both being taken beneath a stump fence bordering some wet woodland, near Kensington. As both are immature I cannot state with certainty the variety, but they appear

[1] Mammals of Ontario, *Proc. Boston Soc. Nat. Hist.*, vol. xxviii, No. 1, pp. 1–44.

[2] A Review of the Squirrels of Eastern North America, *Proc. Biol. Soc. Washington*, vol. x, pp. 145–167.

to be *Peromyscus canadensis.* The scarcity of this species seems remarkable.

4. *Evotomys gapperi.* — A small series was secured, mostly along the borders of woods.

5. *Microtus* ————. — The meadow mouse of Prince Edward Island is apparently an intermediate form between *M. pennsylvanicus* and *M. terrænovæ.* It has the slightly more flaring zygoma and slightly greater interorbital constriction of the latter species. Regarding the enamel pattern of *m 3*, which Bangs[1] considers a characteristic feature of *M. terrænovæ*, I have not been able to distinguish any constant difference between that species and *M. pennsylvanicus*, although I have examined carefully the skulls of both species. The nose patches in my specimens, while more pronounced than in *M. pennsylvanicus* from New Brunswick and other points, are less so than in *M. terrænovæ;* and the color of the back is about intermediate between that of the latter species and of *M. pennsylvanicus* from New Brunswick, some skins having the brownish gray color of New Brunswick specimens, and others the reddish cast of *terrænovæ.* The under parts are similar in *M. terrænovæ*, *M. pennsylvanicus* from New Brunswick, and in the Prince Edward Island skins. The hind foot in *M. terrænovæ* ranges, according to Bangs, from 22 to 25 mm., while in my specimens it varies from 20 to 23 mm.

On the whole, I think the Prince Edward Island specimens are more similar to *M. terrænovæ* than to *M. pennsylvanicus*, but that they represent an intermediate stage between the two species, to which stage the New Brunswick *pennsylvanicus* skins show a decided approach. The specimens of *M. pennsylvanicus* from New Brunswick, to which I have referred in this comparison, came from the northern portion of the province, in the region of the Tobique River. It would, I think, be premature to attempt to name the Prince Edward Island form without having for comparison a series of skins from the coast of New Brunswick, opposite Prince Edward Island, and also from the Magdalen Islands, which lie in the Gulf of St. Lawrence,

[1] Description of a New Field Mouse from Codroy, Newfoundland, *Proc. Biol. Soc. Washington*, vol. ix, pp. 129–132.

between Prince Edward Island and Newfoundland, about seventy miles northeast of the former.

The meadow mouse was one of the commonest mammals of the island, inhabiting sand bars, salt and fresh marshes, and dike lands, as well as damp, bushy clearings abounding in Juncus. They were most numerous on the Cascumpeque sand bar, near Alberton, a long, low, sandy island grown up with *Ammophila arundinacea*, *Achillea millefolium*, and *Arctostaphilos uva-ursi*, and mostly dry, but with a few brackish ponds which communicated with the sea at very high tides. Here the ground was simply honeycombed by their runways.

6. *Fiber zibethicus.* — A common species along the arms of the sea, which make into the island at many points, and in fresh ponds, etc.

7. *Lepus americanus virginianus* (?). — Rabbits were reported as quite common on the island, but I secured only one. This agrees quite closely with specimens of *americanus* (?) from New Brunswick in the American Museum of Natural History, New York, but according to Bangs [1] it is probably *virginianus*. Not having seen any specimens of the hare from farther north, I have been unable to make a satisfactory comparison.

The pelage of my specimen is changing from the summer to the winter stage.

8. *Sorex personatus.* — A common species, occurring mostly in or near wooded swamps. My specimens agree with those from northern Canada, which are larger than those from Pennsylvania and New Jersey, as pointed out by Miller in his "Mammals of Ontario," already mentioned, thus showing perhaps an approach to the Alaskan form *S. streatori*.

The average size of twenty-eight adults is: total length, 103; tail, 45; hind foot, 12.

9. *Sorex hoyi.* — Three specimens of this shrew were all that I secured. They were trapped in or near swampy woods. According to measurements of a number of these shrews from other localities, my specimens are slightly smaller than the average *hoyi*. The average of my specimens is: total length,

[1] The Eastern Races of the American Varying Hare, *Proc. Biol. Soc. Washington*, vol. xii, pp. 77–82.

86; tail, 30; hind foot, 9. The average of five specimens from Ontario (see "Mammals of Ontario," Miller) is: total length, 92; tail, 32; hind foot, 10. (I do not quote any other measurements here, because they were not made in the flesh and are consequently not reliable.)

10. *Blarina brevicauda.*— Only two specimens were secured, both being taken in a small strip of woods bordering a marshy pond at Kensington.

Hypothetical List.

While the following species did not come under my own observation, I obtained records of them from several observers whom I considered trustworthy.

1. *Tamias striatus.* Fairly common. The chipmunks had probably hibernated before I reached the island.
2. *Sciuropterus sabrinus.* Very rare.
3. *Lynx* —————. Very rare.
4. *Vulpes fulvus.* Fairly common.
5. *Ursus americanus.* Occurred formerly.
6. *Lutra canadensis.* Few.
7. *Putorius vison.* Fairly common.
8. *Mustela americana.* Very scarce.

A curious feature of the mammal life of the island is the absence of porcupines and skunks, neither of which, according to reports from several observers, occur on the island, though both are said to occur on the mainland opposite.

All measurements in this paper are in millimeters.

In conclusion I desire to thank Dr. J. A. Allen and Mr. S. N. Rhoads for access to the collections of mammals in their care for comparison.

THE CACTUS BEES; GENUS LITHURGUS.

T. D. A. COCKERELL.

THE common cacti (*Opuntia* and *Echinocactus*) of New Mexico and adjacent regions are freely visited by bees, the females carrying pollen and undoubtedly aiding cross-fertilization. Professor Toumey, who doubtless knows more about cacti in a state of nature than any other man living in this country, has observed and reported the bee visits, without, however, identifying the bees. He has, however, also observed that most of the common cacti (*Opuntia*) about Tucson, Arizona, propagate by means of falling joints which take root, and not by seed; and, as he showed me in his cactus garden last year, certain species have almost lost the power of producing seed. The cactus side of the matter will, I trust, be fully elaborated in due time by Professor Toumey, and I only refer to it now to bring forward the interesting fact that we have a group of plants which are in large part independent of sexual reproduction, but which at the same time possess flowers undoubtedly adapted to bees, and visited by a series of bees more or less peculiar to them. The explanation of this will, I think, be given by Professor Toumey, but in the meanwhile it will be useful to record the bee visitors. The following are the *Lithurgus* records for New Mexico:

(1) *Lithurgus echinocacti* Ckll., 1898. — Two females at flowers of *Echinocactus wislizenii*, one at Mesilla Park (campus of Agricultural College), August 22 (Ckll.), one at La Cueva, Organ Mountains, September 4 (*Townsend*).

(2) *Lithurgus gibbosus* Smith, 1853 (n. syn. *compressus*, Smith, ♂). — Our form has clearer wings than Smith's type. Las Cruces, at flowers of *Opuntia engelmanni*, May 26, 4 ♀, May 25, 1 ♀; May 24, 1 ♂; also observed many other times; both sexes, but especially males, also common at flowers of *Chilopsis linearis* (Bignoniaceæ), May 31 and June 5; Mesilla,

June 19, at flowers of *Cnicus*, 1 ♀; West Fork of Gila River, July 17 (*Townsend*), 1 ♀.

(3) *Lithurgus apicalis* Cresson, 1875. — Santa Fé, June 20, at yellow *Opuntia* flowers, 2 ♂; August 2, at flowers of *Cleome serrulata* (Capparidaceæ), 1 ♂; Santa Fé Cañon, August 11, 7700 ft., inside flowers of *Opuntia arborescens* in wet weather, males; 7600 ft., at flowers of *Cnicus ochrocentrus* (purple-flowered form), females; West Fork of Gila River, July 16, both sexes (*Townsend*). The insect formerly reported from the Mesilla Valley as *apicalis* is *gibbosus*.

These are not the only bees which habitually visit cacti. *Heriades* (*Trypetes*) *gracilior* Ckll., and *Ashmeadiella opuntiæ* (Ckll.) visit the flowers of *Opuntia* in the Organ Mountains in May; while *Ashmeadiella cactorum* (Ckll.) visits *Cactus* (*i.e. Mammillaria*) at Santa Fé in July.[1]

NEW MEXICO AGRICULTURAL EXPERIMENT STATION,
MESILLA PARK, N. M., Feb. 25, 1900.

[1] Since the above was written I have found the bee *Agapostemon texanus* Cress., ♀, visiting flowers of *Cereus polyacanthus* Engelm., det. Wooton, and of *Cereus* sp., prob. *fendleri*, Engelm., in the Mesilla Valley; it burrows down among the stamens so as to be quite lost to sight. Another green bee, *Augochlora neglectula* Ckll., was found by Townsend at La Cueva, Organ Mts., visiting flowers of *Echinocactus wislizenii*.

THE ADVANCE OF BIOLOGY IN 1897.

C. B. DAVENPORT.

THE delay in issuing the magnificent volume of *L'Année biologique* for 1897 is regrettable; but the labor involved in bringing the work of the year into a condition where the result will be quickly accessible is clearly tremendous and the standard of the editors seems to rise from year to year. As in the two previous years, I shall briefly sketch some of the results on which the editors lay most stress.

Cytology. — Important advances were made, especially by Kossel and his pupils in the chemistry of the more active proteids of the cell, and particularly of the spermatozoön. The theory that the centrosome is the center of the cell movements in general received support from its relation to the tail of the spermatozoön and probably (as a series of microsomes) to the cilia of epithelia. The variations in the constitution of the spindle, out of continuous and discontinuous fibres, was made clear. The mechanics of mitosis were further illustrated by the behavior of artificial mixtures and of machines; further evidence for the dependence of membrane formation upon the presence of the nucleus was brought forward.

The Sexual Products and Fecundation. — The variability of the process of chromatin reduction was made clear by the demonstration of the absence of a longitudinal division of the chromosomes, in one instance, and of the absence of any sort of reduction in a second (Lee); the transformations of chromatin during the growth of the ovum were further studied; the idea that polar globules are only aborted eggs received support from Francotte's observation that in polyclads they may be fertilized and develop into gastrulæ. Ivanzov interpreted maturation as an extrusion of ferments that might otherwise destroy the spermatozoön. The conclusion that the centrosome occupies the middle-piece of the spermatozoön gained a general

acceptance. The presence of antherozoid in gymnosperms was demonstrated.

In the field of *fertilization* studies, the opinion that the centrosome of the fertilized egg comes exclusively from the sperm was still dominant, despite the contradiction of Myzostoma; but the continuity of the centrosome was still debated.

Parthenogenesis. — A difference in structure between the parthenogenetic and the sexual egg of Rotifera was affirmed, and it was asserted that while in the female parthenogenetic egg of Rotifera only one polar globule is formed, two are permanently extruded when the parthenogenetic egg is destined to produce a male.

Asexual Reproduction. — It has long been recognized that the organs of an individual produced by budding or fission develop differently from those of an egg-individual. This difference can be referred to the dissimilarity of external conditions in the two cases. Thus von Bock showed that in dividing Chætogaster the mouth of the new zoöid arises from two lateral invaginations instead of one ventral one, because the ventral position of the nerve cord interferes with a median invagination. Heschler showed that the regenerative capacity of the earthworm is greatest in the region where autotomy normally occurs. Bordage extended our knowledge of autotomy in Orthoptera.

Ontogenesis. — Echoes of the preformation-epigenesis controversy continued. Fischel, working with isolated blastomeres of ctenophores (Beroë), concludes that they afford a good example of preformation. Attempts to influence development by external means were richly rewarded. Hertwig transformed the holoblastic egg of the frog into a meroblastic one by condensing the yolk by means of a centrifugal machine. It was shown that salamander eggs reared in the dark became in certain particulars abnormal, and that electric rays accelerate the respiration of the eggs of the silkworm and hasten their hatching.

Teratogenesis. — Especially important is the experiment of Tornier, by which doubly and triply tailed lizards may be produced by making a triangular incision through the muscles and into the vertebræ. Also if a limb is transsected and a thread

be tied so as to divide the free surface of the stump, two appendages will arise. A lesion of the humerus may provoke the development of an extra limb.

Regeneration. — It was shown by Miss Peebles that in Hydra there are slight differences in the regenerative capacity of the different parts of the body, since the foot regenerates less well than the lateral parts of the trunk; also that $\frac{1}{200}$ of a Hydra will regenerate. Morgan enumerated certain laws of regeneration of the earthworm. The parallelism of regeneration and ontogeny was still debated. The truth that the essence of regeneration is not the restoration of some lost part, but the reassumption of the specific form, was illustrated by the regeneration of a jellyfish and a hydroid.

Grafting. — As the results of Born and Jœst marked respectively the years 1895 and 1896, so those of Crampton on the pupæ of Lepidoptera marked 1897. In Lepidoptera, as in tadpoles and earthworms, the grafted pieces, even if belonging to distinct species, exert no mutual effect. In plant grafting, however, Daniel got a reciprocal effect.

Sex. — No important advance in this subject was made in 1897. Nussbaum, working on rotifers, got in some cases, as Maupas did, a predominance of females. This was due, Nussbaum thinks, to an excess of food rather than a low temperature, as Maupas concluded.

Polymorphism and Metamorphosis. — The most interesting result was the rearing of an Amblystoma to the adult stages with retention of gills, by means of good food and a high temperature.

Correlation. — False correlation was studied and measured by Pearson and discussed by Galton. Warren determined quantitatively the correlation between the various parts of the human skeleton.

General Morphology and Physiology. — Contributions were made opposing the old interpretation of the germ layers. The science of general physiology was becoming outlined with the aid of new text-books. The importance of ions in physiology received new and stronger confirmation; the correlation between the composition of milk and the rate of infantile develop-

ment of various species was demonstrated. The important rôle of water in growth was pointed out. Nencki (following Tschirsch, '96) showed that the close relation between chlorophyl and hæmoglobin indicated their phylogenetic development out of one fundamental substance before animals and plants diverged. The organic food taken up by plants through their roots was further studied, and the old theory that plants feed exclusively on inorganic compounds received many hard blows. These discoveries, taken with the facts of the fundamental rôle of inorganic salts for animal nutrition, are breaking down the old distinctions drawn between animal and plant nutrition. Further valuable studies were made on the formation of albumen in plants. Muscle contraction, the electric organs, inflammation of wounded plants were newly studied. Dubois afforded much new data on hibernation. The literature on ferments grew rapidly, but not faster than the importance of the subject warrants. The reactions of organisms to light, heat, gravity, and electricity were further studied (Jennings, Loeb, and others). Czapek gives an account of the chemical differences between stimulated and unstimulated plant protoplasm.

Heredity. — Little was done on the important question of inheritance of the acquired. Whitman showed that in hybrid pigeons the period of incubation was the same as in the normally fertilized egg of the female species, and was uninfluenced by the fact that the species of the male was shorter brooded. Early developmental processes, then, are determined by the cytoplasmic peculiarities of the egg. Other experiments in hybridization were made.

Variation. — Applications of the quantitative methods of studying variation to particular problems began to appear. Brewster showed that those characters which are most variable in the individuals of a species are especially those in which the species of a genius differ. Bumpus found the house-sparrow, introduced into America, more variable than in Europe and concludes that its greater variability is the result of the partial withdrawal of natural selection.

Origin of Species. — Noteworthy are the book of Romanes on Darwinism, and C. L. Morgan and H. F. Osborn's theory of

evolution. Many workers pleaded for an explanation of adaptation on the basis of self-adjustment. No real progress was being made in this field, because the method was bad.

Geographic Distribution. — There was especial activity in the study of marine and fresh-water plankton and the theory of bipolarity in the distribution of faunas. Of general works may be cited Lydekker on mammals in general and Sclater on marine mammals.

Mental Functions. — The review of the literature in this department occupies one-fifth of the book. The work is too voluminous and technical to be summarized here.

General Theories. — Very little. A duel between Hertwig and Roux over the word "Entwickelungsmechanik." A suggestive work by Pearson on "The Chances of Death."

General biology has this year made its greatest advances in the study of variation, grafting, in general physiological problems, and in the chemistry of vital phenomena.

ON THE INTERPRETATION OF UNUSUAL EVENTS IN GEOLOGIC RECORDS ILLUSTRATED BY RECENT EXAMPLES.[1]

FREDERIC W. SIMONDS.

An examination of many geologic reports will not fail to show that the working geologist, as a rule, devotes but little time to the interpretation of events, though the most valuable data may be furnished by the very rocks which, as a stratigrapher, he indicates on his map or describes in his notebook. To search out relations of rocks stratigraphically is, of course, one thing; to picture in the mind the conditions that prevailed at the time of their deposition is another and a different thing. But while none will dispute the value of stratigraphic work, the value of interpretation should not be underestimated, for by it we gain our clearest insight into the physical conditions of the past. That it is to a great extent theoretical may be admitted, yet the results of indirect evidence may approximate the truth. In this paper it is my purpose to show that under some conditions, especially when unusual events have been recorded, there is not only difficulty in making the proper interpretation, but even danger that the interpretation may become misleading — a partial truth being, under some circumstances, conducive to positive error.

Throughout the various ages of the earth, as represented by sedimentary deposits, faunas have succeeded faunas, and floras have succeeded floras. At times the exuberance of life must have been great, so numerous are the imbedded remains; but whether numerous or scarce, they are especially useful to the working geologist in that they enable him to recognize strata. As fossils they are figured and described by the paleontologist, who views them mainly from a biologic standpoint. They also

[1] Read before Section E, Geology and Geography, American Association for the Advancement of Science, August 23, 1899.

furnish valuable data in solving problems of descent and explain to the biologist certain obscure points in the structure of living forms. But they afford evidence of another kind, the value of which is determined by the ability of the observer to make a correct interpretation. They may reveal much concerning the habits of species, whether terrestrial or aquatic, and their habitat ; they may give clues to temperature and other details upon which climate depends; they may indicate, if the species be aquatic, the nature of the water, whether fresh, salt, or brackish, whether shallow or deep, whether cold or warm, etc. It is from his knowledge of existing conditions of life and growth that the observer is able to interpret the conditions attendant upon certain characteristic growth of the past : that, for example, bright, clear skies, and pure sea-water, of not too great depth and free from the chilling influence of cold currents, are conducive to a profusion of coral growth ; that alternate exposure to sea and air is satisfactory to mussels and other littoral species ; that clams thrive best in the sand and mud banks exposed between the tides. Knowledge of this kind enables the acute observer to gain a certain amount of *historical* insight, when kindred forms are found in strata, concerning the conditions that have prevailed upon the earth in remote times of which there is left no direct record.

It must be admitted, also, that a correct interpretation involves much evidence other than that afforded by organic remains. The rocks themselves, irrespective of their fossil contents, afford most valuable data respecting the conditions attendant upon their deposition : mud, for instance, indicating turbulent times, erosion and waste of land surfaces, heavy rainfalls, swollen rivers, and flooding ; foraminiferal ooze and other fine-grained calcareous matter, deep-sea deposits ; sand and gravel, beach deposits. Data of this kind are not to be ignored ; nor are those changes, such as the thickening and thinning of strata, the passage of limestone beds into shale or sandstone, or the reverse, which may indicate that the deposition had taken place near to or far from land masses. The information thus derived is to be woven into the record ; it is essential for a complete interpretation.

As a student of geology I was long ago impressed with the masterly interpretation of the Brier Hill Coal Seam of Ohio as presented in the *School of Mines Quarterly* (April, 1883) by the late Professor Newberry. The plan, it seemed to me, was admirable. First, the facts were given ; then, from them, was translated the history. The statement of facts is a matter dependent upon observation ; it may be full and minute, or of a more general nature, according to the care and skill of the observer. Facts relative to the occurrence of coal in a certain area may be simply recorded as facts, a plan pursued in many geologic reports, which is eminently proper from an economic standpoint, as it enables the practical man to locate seams, and that is all he desires. But, from the standpoint of pure science, where *knowledge* is the object to be attained, and not wealth, the point of view is different. The facts must be made to reveal more than the order of succession of strata, the areas covered, the thickness and kinds of rock composing the individual layers; they must be interpreted, and this must be, to a great extent, the work of the *imagination*, the revivifying of a skeleton by the addition of flesh.

This, the *speculative* side of geology, if I may so call it, is particularly attractive to some scholars. It cultivates the same faculties, employs the same modes of reasoning, so widely used by the ethnologist, who, from the exhumed remains, ornaments, utensils, from the shell heaps and rude weapons, learns much of the habits — the life — of extinct peoples.

Granted, then, that much must be speculative, and purely so, he is the best interpreter who can bring his imaginary picture nearest in accord with facts. Ultimately, then, the interpretation is resolved into a matter of probability, based upon data furnished by observation, but it is, nevertheless, a creation of the mind. Herein lies one of the greatest difficulties : conceded that the observations have been carefully and properly made, extreme caution must be employed in drawing conclusions, lest, by a *mental* slip, error and not truth be the result.

As I have already intimated, the proper interpretation of paleontologic evidence, supplemented by the data furnished by the rocks themselves, gives us a somewhat definite idea of the

climate and other physical conditions of a past age, acquaints us with the habits and habitat of species, whether animals or plants, and elucidates many interesting and intricate points concerning their growth, development, and distribution; in short, it enables us to reanimate and reëstablish that age. But all of this must be done, directly or indirectly, in accordance with the light of the present time. We have, it is true, familiarized ourselves with usual events, yet we know that the unusual does sometimes happen, and if now, why not in the past?

That an unusual event in the paleontologic record, judging entirely from present events, might be a source of considerable difficulty, or of positive error in interpretation, cannot be doubted. Let me illustrate: Some years ago, as the result of a heavy storm, fish in large numbers were thrown ashore in certain localities bordering on the Bay of Fundy. Let us suppose this to be a region of rapid sedimentation and that their remains were quickly entombed. Had this event taken place in another age, and had the sediment afterwards been elevated and lithified, then would these remains have afforded suitable material for interpretation. But what should the translation indicate? An unusual abundance of fish — conditions favorable to the growth and development of this form of life which had been suddenly interrupted? If that, the whole truth would not be told. By an unusual event, *viz.*, a heavy storm, fish remains that under ordinary circumstances would have been distributed over a wide area are accumulated within a small area, and, further, remains that under normal conditions would have ranged through a considerable space vertically, are limited to a single layer or a few layers of the deposit. Under such conditions the abundance of fish is apparent rather than real. Other interpretations might be made; that, for instance, owing to an epidemic, fish perished in large numbers; or, again, that a sudden and great decrease in temperature caused the marked fatality.

It will be seen that while each of the above interpretations appears adequate to account for the phenomenon, none have given the complete truth, though in all the occurrence of *an*

unusual event has been recognized. The action of the heavy storm is the truth sought but not brought out.

It is fortunate that as the result of an unusual occurrence witnessed by Dr. Joseph Le Conte a rational explanation can be made of the conditions under which insects may be collected in vast numbers within the confines of a single stratum. As ordinarily interpreted, the contents of such a bed would indicate that this particular form of life existed in greater abundance at the time of its deposition than either before or after; whereas, as shown by Dr. Le Conte, the abundance of insect remains may be due to concentration — a perfectly natural result though brought about by unusual conditions. He says:

"On Lake Superior, at Eagle Harbor, in the summer of 1844, we saw the white sands of the beach blackened with the bodies of insects of many species, but mostly beetles, cast ashore. As many species were here collected in a few days, by Dr. J. L. Le Conte, as could have been collected in as many months in any other place. The insects seem to have flown over the surface of the lake; to have been beaten down by winds and drowned, and then slowly carried shoreward and accumulated in this harbor, and finally cast ashore by winds and waves. A small river emptying into the harbor carried also many beetles and ants. Doubtless," he continues, "at Oeningen, in Miocene times, there was an extensive lake surrounded by dense forests, through which ran a small river emptying into the lake; and the insects drowned in its waters, and the leaves strewed by the winds on its surface, were cast ashore by its waves." [1]

Again, at the mouth of the Mackenzie River a vast quantity of driftwood is accumulating at the present time, which Sir Charles Lyell long ago predicted would, at some distant period, form a great deposit of coal. Now this accumulation of vegetable matter is that having its origin in a much warmer and well-wooded region. By the flooding of a great stream it is conveyed to its final resting place, which is a locality both climatically and biologically different — a region of low temperature and scant vegetation. Let us suppose that the buried

[1] *Elements of Geology*, Fourth Edition, p. 534.

accumulation has become coal. An interpretation that the contained tree-trunks represented the vegetable life of that region would be, in the highest degree, erroneous. The lowly terrestrial plants of the vicinity may have entirely disappeared, or their remains, commingled with those of a forest vegetation, may attract little or no attention. Granted, however, that the alluvial barriers may be discovered, that the true character of the deposit may be determined, still there is an unusual event to be translated, namely, the enormous distance the vegetable matter has been transported. To recognize this may be extremely difficult, if not impossible. During the lapse of time, elevation and folding may have taken place; denudation and erosion may have completely altered the topography of so vast an area of country; parts of the great river basin may have become so widely separated that their continuity would scarcely be suspected. This is not an exaggerated statement; on the contrary, it lies strictly within the limits of possibility. If so, then is the danger of misinterpretation clearly shown.

The flooding of streams, it is said, is often quite destructive of fish life; the copious sediment contained in the water being an undoubted cause of suffocation. During the recent flood in Texas I saw fish so overcome that they were easily taken by hand. When the waters receded their dead bodies were reported as occurring along the river banks and on the bars. Under such conditions it does not seem improbable that parts of the skeleton, and especially the scales, such as those of the ganoid type, should be borne seaward, and finally deposited in salt water, commingled with marine forms. Had a similar circumstance occurred in other than recent time, and had the remains of marine and fresh-water forms been preserved in the same stratum, then a fine discrimination between animals greatly alike in appearance, and, possibly, not presenting characters admitting of direct relations with the present, becomes necessary on the part of the observer would he make a correct interpretation. And, moreover, this hypothetical statement will serve to emphasize the fact that a knowledge of biology is of prime importance to him who would undertake the interpretation of such a record.

Cases might be multiplied, but the point I wish to make is apparent: an interpretation of the history recorded in strata is an absolute necessity if we are to picture the past. Recorded facts must be made to reveal unrecorded events. It is only from the conclusions drawn that we can give the picture life; if they be wrong, the picture becomes distorted, perchance a monstrosity. Unusual events now happen, hence our right to believe that they have happened in the past. They are at times shrouded in deep obscurity — hidden, it may be, in a mass of intricate details. Often they are confined to a single locality, but they may affect an unusually large area. However this may be, the greatest care is necessary lest we pass them by unnoticed, and the greatest caution, should they be discovered, lest we misinterpret them. Human speculation does not always admit of proof, but when based upon facts, as it should be in geologic interpretation, it may at least approximate the truth.

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SYNOPSES OF NORTH-AMERICAN INVERTEBRATES.

X. The Oxyrhynchous and Oxystomatous Crabs of North America.

MARY J. RATHBUN.

The Oxyrhyncha include the large family of Maiidæ, or "spider crabs," so called on account of their slender legs. The body is usually narrow in front, sometimes suborbicular, but always with a beak or rostrum, as in the common "spiders" (Libinia) of the Atlantic coast. The Maiidæ are all provided with numbers of hairs, either hook-shaped or straight, varying in form and arrangement in the different genera and species. In order to conceal themselves from enemies these crabs cover their backs with algæ and sedentary animals, as sponges, tunicates, and bryozoans, which are held fast by the hairs and live and grow until their host is unrecognizable. This is notably so in *Oregonia gracilis*. Some species, as those of Collodes, are covered with slimy adherent mud.

The Parthenopidæ, the second and smaller division of the Oxyrhyncha, are easily distinguished by their broad, triangular carapace, very long, usually trigonal chelipeds, and short, delicate walking legs. They often resemble fragments of stone with sharp angles, or with eroded or nodular surfaces.

The Oxystomata comprise several families widely different in their general appearance. Of the Calappidæ the best known are the species of Calappa, "box crabs," or "shamefaced crabs," from the chelipeds which are large and of unusual shape, with cockscomb-like crests on the upper margin of the hands, and which in flexion are pressed tightly against the inferior surface of the carapace like a shield. This arrangement is said to protect from attack any morsels of food they may be devouring.

The Calappa lives usually on sandy shores, into which it is in the habit of burrowing.

Of the Matutidæ, which are sparsely represented in North America, the species of Hepatus are large and strikingly colored. They differ from Calappa in the smaller claws and in the narrower posterior portion of the shell. *Hepatus epheliticus* is known on the Gulf coast as "Dolly Varden."

The Leucosiidæ are generally distinguished by their globular carapace, long claws, and comparatively small walking feet. The largest and most conspicuous North-American species are the *Persephona punctata*, or "speckled spider," of the Atlantic and Gulf coasts, and *Randallia ornata* of the Pacific coast.

The Dorippidæ are marked by the reduction of the last two pairs of feet, which are raised on the dorsal surface of the carapace. The first two pairs of walking legs are long, enabling the crab to run fast.

In the key which follows, the same terms are used to indicate distribution as in No. VII of these synopses; and, as in that number, many of the definitions have been taken from the works of Drs. Stebbing and Alcock.

TRIBE OXYRHYNCHA, OR MAIOIDEA.

Carapace narrowed anteriorly and rostrate, with the hepatic regions small, the branchial large. Epistome generally large. Buccal frame quadrate, with anterior margin straight. Nine pairs of branchiæ, with the efferent channels opening at the sides of the endostome. The afferent channels open behind the pterygostomian regions, in front of the bases of the chelipeds. First antennæ longitudinally folded. Third maxillipeds with the fifth joint articulated at the apex or at the front inner angle of the fourth. The genital organs of the male are inserted at the bases of the last pair of trunk legs.

KEY TO THE FAMILIES OF THE TRIBE OXYRHYNCHA.

A. Basal joint of antennæ well developed. Chelipeds not a great deal longer than the other legs . . . . MAIIDÆ Leach

A'. Basal joint of antennæ very small, and imbedded between the front and the floor of the orbit. Chelipeds a great deal longer and more massive than the other legs

PARTHENOPIDÆ Milne-Edwards, White

Key to the Genera of the Family Maiidæ.

A. Basal joint of antennæ extremely slender throughout its length and usually long. Eyes without orbits and not concealed.

B. Carapace elongate, narrowed in front. External maxillipeds somewhat pediform, with the palp large and coarse, and the merus often narrower than the ischium. Basal joint of antennæ usually subcylindrical.

C. Rostrum extremely long. Dactyli of ambulatory legs longer than the propodi.

D. Carapace smooth, even above. Antennæ concealed beneath the rostrum . . . . Stenorynchus

D′. Carapace uneven above. Antennæ long, flagellum exposed . . . . Metoporhaphis

C′. Rostrum short. Dactyli of ambulatory legs shorter than the propodi . . . . Podochela

B′. Carapace usually subtriangular. External maxillipeds with the merus at least as broad as the ischium, and the palp small. Basal joint of antennæ flattened or concave ventrally.

C. Rostrum simple, or with two short spines or lobes.

D. No postocular spine or tooth.

E. Chelipeds not much elongated, palms inflated. Rostrum emarginate . . . . Æpinus

E′. Chelipeds much elongated, with palms long and slender. Rostrum simple . . . . . Erileptus

D′. A postocular spine or tooth.

E. Eyes long and slender . . . . . . Arachnopsis

E′. Eyes not long and slender.

F. Inner crest of basal antennal joint very prominent and projecting downward at right angles to the outer crest.

G. Postocular tooth pointing forward.

H. Postocular tooth fitting close to the eye . . . . Dasygyius

H′. Postocular tooth not fitting close to the eye . . . . . . Inachoides

G′. Postocular tooth pointing outward Collodes

F′. Inner crest of basal antennal joint, when present, not projecting downward at right angles to the outer crest.

G. Rostrum simple . . . . . . Anasimus

G′. Rostrum bifid.

H. Spine of basal antennal joint not advanced to the line of the front.

Hepatic region approximating the eye, its anterior margin transverse Batrachonotus

H′. Spine of basal antennal joint advanced to the line of the front or nearly so. Hepatic region distant from the eye, its anterior margin oblique Euprognatha

C′. Rostrum composed of two long spines . . . . Oregonia

A′. Basal joint of antennæ not extremely slender, often very broad. Eyes with orbits, or capable of concealment.

B. Basal joint of antennæ truncate-triangular. Eyes without true orbits; eyestalks very short, either concealed beneath a supra-ocular spine or sunk in the sides of a huge beak-like rostrum.

C. Antennæ concealed beneath the rostrum.

D. Rostrum formed of two long contiguous horns Sphenocarcinus

D′. Rostrum not formed of two long contiguous horns.

E. Eyes immovable . . . . Mocosoa

E′. Eyes movable . . . . Epialtus

C′. Antennæ not concealed beneath the rostrum.

D. Entire lateral portion of carapace wing-like. Carapace smooth or nearly so . . . . Mimulus

D′. Carapace with two large lobes or teeth on each side. Carapace tuberculate . . . . Pugettia

B′. Basal joint of antennæ broad, usually either extensively produced outward or, often, with one or two distal spines. Eyes with orbits.

C. Orbits with a large, blunt, cupped postocular process into which the eye is retractile, but is not completely concealed. Eyestalks short.

D. No preocular spine.

E. Meral joints of ambulatory legs flattened.

F. Carapace nearly as broad as long; surface uneven . . . . Chionœcetes

F′. Carapace much longer than broad; surface smooth . . . . Pelia

E′. Meral joints of ambulatory legs subcylindrical Hyas

D′. A preocular spine.

E. Ambulatory legs armed with spines . . . Nibilia

E′. Ambulatory legs not armed with spines.

F. Basal joint of antenna deeply concave; second and third joints flattened, with thin, broad, lateral expansions . . . . Scyra

F′. Basal joint of antenna not deeply concave; second and third joints not broadly expanded.

G. Rostral horns long and slender . Chorilia

G′. Rostral horns not long and slender.

H. Basal antennal joint narrowing distally . . . . Rhodia

H′. Basal antennal joint not narrowing distally . . . . . Loxorhynchus

C′. Orbits complete, often tubular, completely concealing the retracted eye.

D. Meral joints of ambulatory legs with very broad laminate expansions . . . . Hemus

D′. Meral joints of ambulatory legs without laminate expansions.

E. Fingers spoon-shaped at tips.

F. Carapace suboblong or suboval. Orbits directed forward. First movable joint of antennæ broadly expanded. Legs unarmed Pitho

F′. Carapace subtriangular. Orbits directed obliquely forward. First movable joint of antennæ not broadly expanded. Legs spinous . . . . Mithrax

E′. Fingers acute at tips.

F. Orbits tubular, directed outward. Carapace subtriangular or oblong.

G. Carapace with lateral spines . . Stenocionops

G′. Carapace without lateral spines Macrocœloma

F′. Orbits not tubular, directed obliquely forward. Carapace orbicular.

G. Basal joint of antennæ with two spines on the inferior margin of the orbit Cœlocerus

G′. Basal joint of antennæ without spines on the inferior margin of the orbit Libinia

The Species of Maiidæ.

Genus Stenorynchus Lamarck . *S. sagittarius* (Fabricius), *M(CH)SG*
Genus Metoporhaphis Stimpson . . . *M. calcarata* (Say), *M(CH)SG*
Genus Podochela Stimpson.

Key to Species.

A. Rostrum acute or spiniform.

B. Rostrum long-pointed, terminating in a slender spine
P. gracilipes Stimpson, *M(CH)SG*

B'. Rostrum short-pointed, not terminating in a spine.

C. A large postorbital tooth near the eye
P. lamelligera (Stimpson), *G*

C'. A small postorbital tubercle, remote from the eye
P. hemphillii (Lockington), *D*

A'. Rostrum not acute, but rounded.

B. Pterygostomian region with a laminate crest. Basal antennal joint with lateral crests laminate *P. riisei* Stimpson, *M(CH)G*

B'. Pterygostomian region with a tubercle. Basal antennal joint with lateral crests smooth and rounded *P. hypoglypha* (Stimpson), *G*

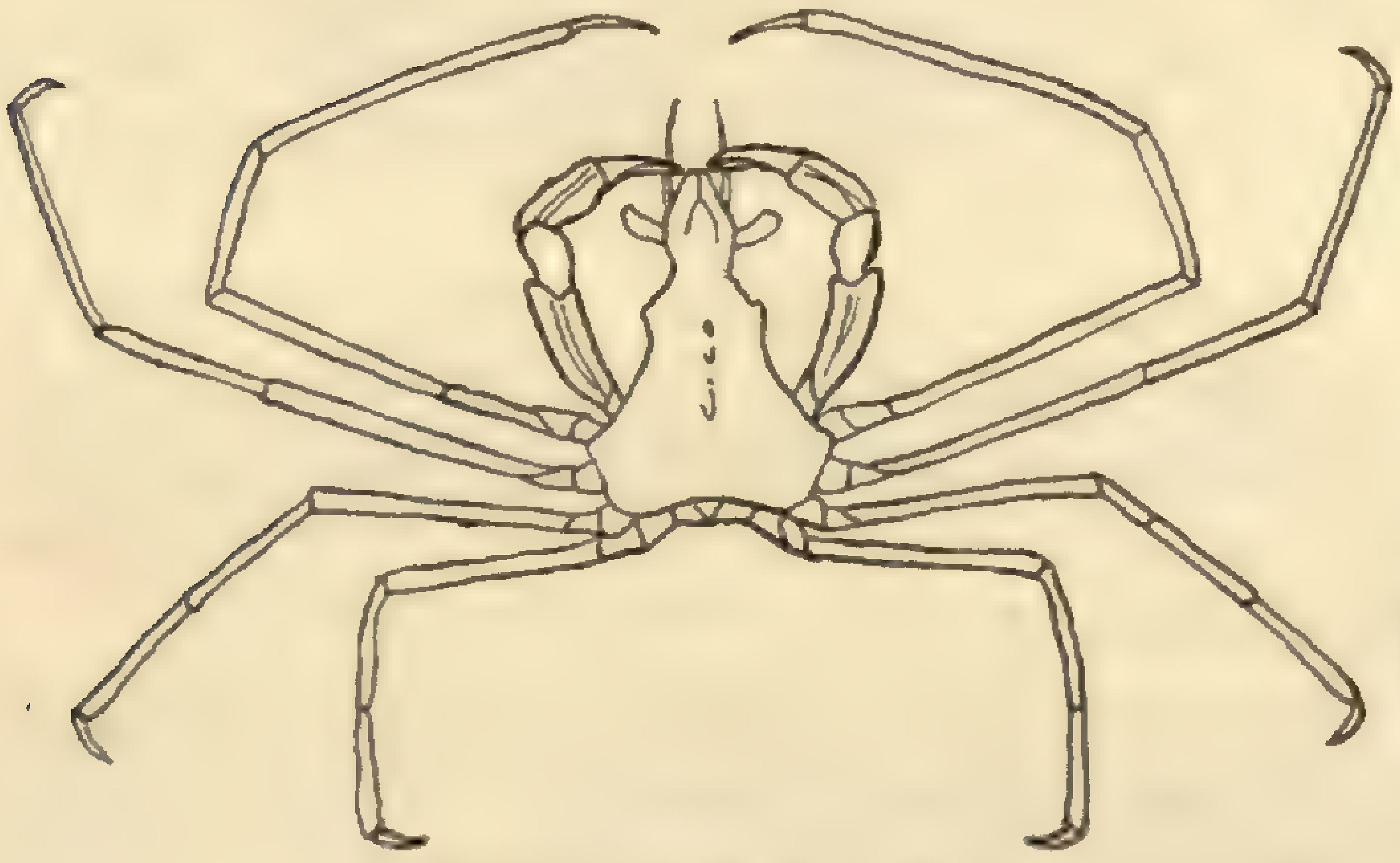

FIG. 1. — Podochela riisei.

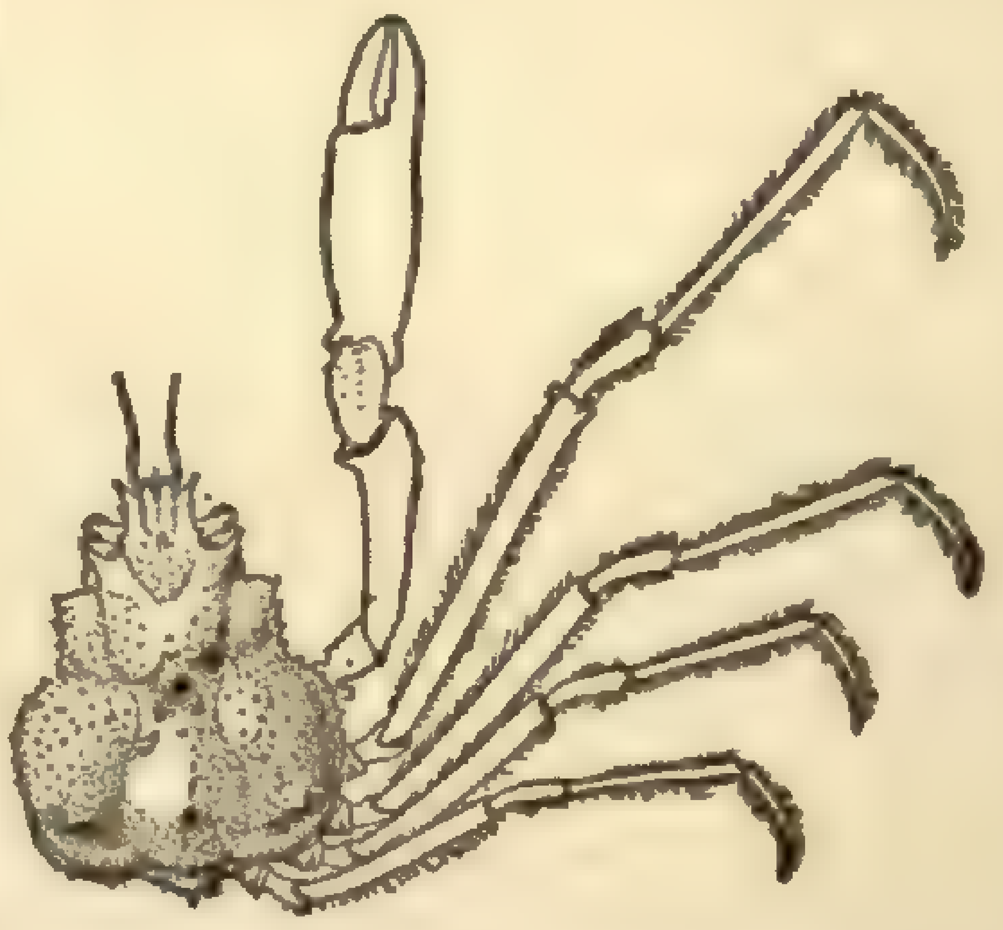

FIG. 2. — Euprognatha rastellifera.

Genus Æpinus Rathbun . . *A. septemspinosus* (A. Milne-Edwards), *G*
Genus Erileptus Rathbun . . . . *E. spinosus* Rathbun, *D*
Genus Arachnopsis Stimpson . . . . *A. filipes* Stimpson, *G*
Genus Dasygyius Rathbun . . . . *D. tuberculatus* (Lockington), *D*
Genus Inachoides Milne-Edwards Lucas . *I. magdalenensis* Rathbun, *D*
Genus Collodes Stimpson.

Key to Species.

A. Carapace with median spines
C. depressus A. Milne-Edwards, *M(CH)SG*

A'. Carapace without median spines.

B. Interantennular spine advanced as far as the rostrum
C. leptocheles Rathbun, *G*

B'. Interantennular spine not advanced as far as the rostrum
C. robustus Smith, *M*

Genus Anasimus A. Milne-Edwards.

Key to Species.

A. Ambulatory legs more than twice the length of the carapace
A. latus Rathbun, *SG*

A'. Ambulatory legs less than twice the length of the carapace
A. rostratus Rathbun, *D*

Genus Batrachonotus Stimpson . . . *B. fragosus* Stimpson, *M(CH)G*

Genus Euprognatha Stimpson . . . . *E. rastellifera* Stimpson, *MS*

Genus Oregonia Dana . . . . *O. gracilis* Dana, *AP*

Genus Sphenocarcinus A. Milne-Edwards
S. corrosus A. Milne-Edwards, *M(CH)*

Genus Mocosoa Stimpson . . . . . . *M. crebripunctata* Stimpson, *G*

Genus Epialtus Milne-Edwards.

Key to Species.

A. First tooth of the antero-lateral margin large and prominent.
B. No postocular tooth . . *E. bituberculatus* Milne-Edwards, *D*

FIG. 3. — Epialtus productus.

B'. A postocular tooth . . . . . . *E. productus* Randall, *APD*

A'. First tooth of the antero-lateral margin small, not prominent
E. nuttallii Randall, D

Genus Mimulus Stimpson . . . . *M. foliatus* Stimpson, *APD*

Genus Pugettia Dana.

Key to Species.

A. Postorbital projection a triangular tooth.
B. Hepatic expansion very broad . . . *P. gracilis* Dana, *APD*[1]
B'. Hepatic expansion narrow, transverse . . *P. richii* Dana, *AD*

[1] San Luis Obispo, California (Lockington).

A′. Postorbital projection an obtuse lobe . . . . *P. dalli* Rathbun, *D*

Genus Chionœcetes Krøyer.

Key to Species.

A. Carapace tuberculous ; branchial regions flattened
C. opilio (O. Fabricius), *NA*

A′. Carapace spinous ; branchial regions dilated
C. tanneri Rathbun,[1] *APD*

Genus Pelia Bell.

Key to Species.

A. Hands in male with margins tapering to the fingers, which have their edges meeting throughout . . *P. pacifica* A. Milne-Edwards, *D*

FIG. 4.—Chionœcetes tanneri.

A′. Hands in male with margins subparallel; fingers gaping at base
P. mutica (Gibbes), *MSG*

Genus Hyas Leach.

Key to Species.

A. Carapace subtriangular; hepatic region not dilated laterally. Basal antennal joint subtriangular . . . . *H. araneus* (Linnæus), *N*

A′. Carapace lyrate; hepatic region dilated laterally. Basal antennal joint with sides nearly parallel.

B. Posterior angle of hepatic projection rounded. Basal antennal joint without a large tubercle at the antero-external angle
H. coarctatus Leach, *NMA*

B′. Posterior angle of hepatic projection subacute. Basal antennal joint with a large tubercle at the antero-external angle
H. lyratus Dana, *AP*

Genus Nibilia A. Milne-Edwards
N. erinacea A. Milne-Edwards, *M(CH)G*

Genus Scyra Dana . . . . *S. acutifrons* Dana, *APD*

Genus Chorilia Dana . . . . *C. longipes* Dana, *APD*

[1] Only in exceptional cases has this species been found above the 100-fathom line.

Genus Rhodia Bell . . . . *R. parvifrons* (Randall), *D*
= *Herbstiella camptacantha* Stimpson

Genus Loxorhynchus Stimpson.

Key to Species.

A. Hepatic region with two large spines . . *L. grandis* Stimpson, *PD*
A'. Hepatic region with one large spine . . *L. crispatus* Stimpson, *D*
Genus Hemus A. Milne-Edwards . *H. cristulipes* A. Milne-Edwards, *G*
Genus Pitho Bell.

Key to Species.

A. Carapace smooth, pubescent . . . *P. anisodon* (von Martens), *G*

Fig. 5. — Hyas lyratus.

A'. Carapace tuberculous . . . . *P. lherminieri* (Schramm), *S*
Genus Mithrax Latreille.[1]

Key to Species.

A. Carapace with dorsal sulci on the branchial regions
M. forceps (A. Milne-Edwards), *M*(*CH*)*S*
A'. Carapace without dorsal sulci on the branchial regions.
B. Divisions of rostrum tuberculiform.
C. Tubercles of the carapace faintly indicated
M. hispidus (Herbst), *S*
C'. Tubercles of the carapace well marked
M. pleuracanthus Stimpson, *M*(*CH*)*SG*

[1] *M. denticulatus* Bell, *M. tuberculatus* Stimpson, and *Teleophrys cristulipes* Stimpson are recorded from California by Miers, but this is very likely an error, as Miers used "California" and "Lower California" interchangeably.

B'. Divisions of rostrum long and sharp *M. acuticornis* Stimpson, *G*

Genus Stenocionops Leach.

Key to Species.

A. Carapace with strong median spines
S. spinosissimus (Saussure), *M(CH)*

A'. Carapace without strong median spines.
B. Carapace smooth . . . . *S. furcatus* (Olivier), *S*

FIG. 6. — Chorilia longipes.

FIG. 7. — Pitho anisodon.

B'. Carapace tuberculous *S. furcatus cœlatus* (A. Milne-Edwards), *G*

Genus Macrocœloma Miers.

Key to Species.

A. Carapace with dorsal spines besides the epibranchial and posterior spines.
B. Rostrum strongly deflexed *M. septemspinosum* (Stimpson), *SG*

B'. Rostrum almost horizontal . . *M. camptocerum* (Stimpson), *G*

A'. Carapace without dorsal spines except the epibranchial and posterior spines . . . . *M. trispinosum* (Latreille), *M(CH)G*

Genus Cœlocerus A. Milne-Edwards . . . . *C. grandis* Rathbun, *G*

Genus Libinia Leach.

Key to Species.

A. Carapace with lateral margin evenly rounded behind the rostrum.

B. Median spines six . . . . . *L. dubia* Milne-Edwards, *MSG*

B'. Median spines nine . . . . *L. emarginata* Leach, *NMSG*

A'. Carapace distended at the hepatic regions *L. spinimana* Rathbun, *G*

Fig. 8. — Mithrax acuticornis.

Fig. 9. — Macrocœloma camptocerum.

Key to the Genera of the Family Parthenopidæ.

A. Carapace not laterally expanded.

B. Carapace tuberculate.

C. Carapace triangular, convex. Pterygostomian and subhepatic regions not deeply excavated to form passages to the efferent branchial apertures . . . . Lambrus

C'. Carapace subrhomboidal, depressed. Pterygostomian and subhepatic regions excavated, this excavation forming, when the chelipeds are retracted, passages to the efferent branchial apertures . . . . Platylambrus

B'. Carapace smooth . . . . Solenolambrus

A'. Carapace more or less expanded to form a vault in which the ambulatory legs are concealed.

B. Carapace greatly expanded, both laterally and posteriorly Cryptopodia

B'. Carapace expanded laterally, but not posteriorly . Heterocrypta

The Species of Parthenopidæ.[1]

Genus Lambrus Leach.

Key to Species.

A. Carapace subtriangular, with lateral angles.

B. Protuberances of the carapace spiniform, subacute
L. pourtalesii Stimpson, *MS*

B′. Protuberances of the carapace tuberculiform, broadly rounded at the top . . . . *L. fraterculus* Stimpson, *M(CH)G*

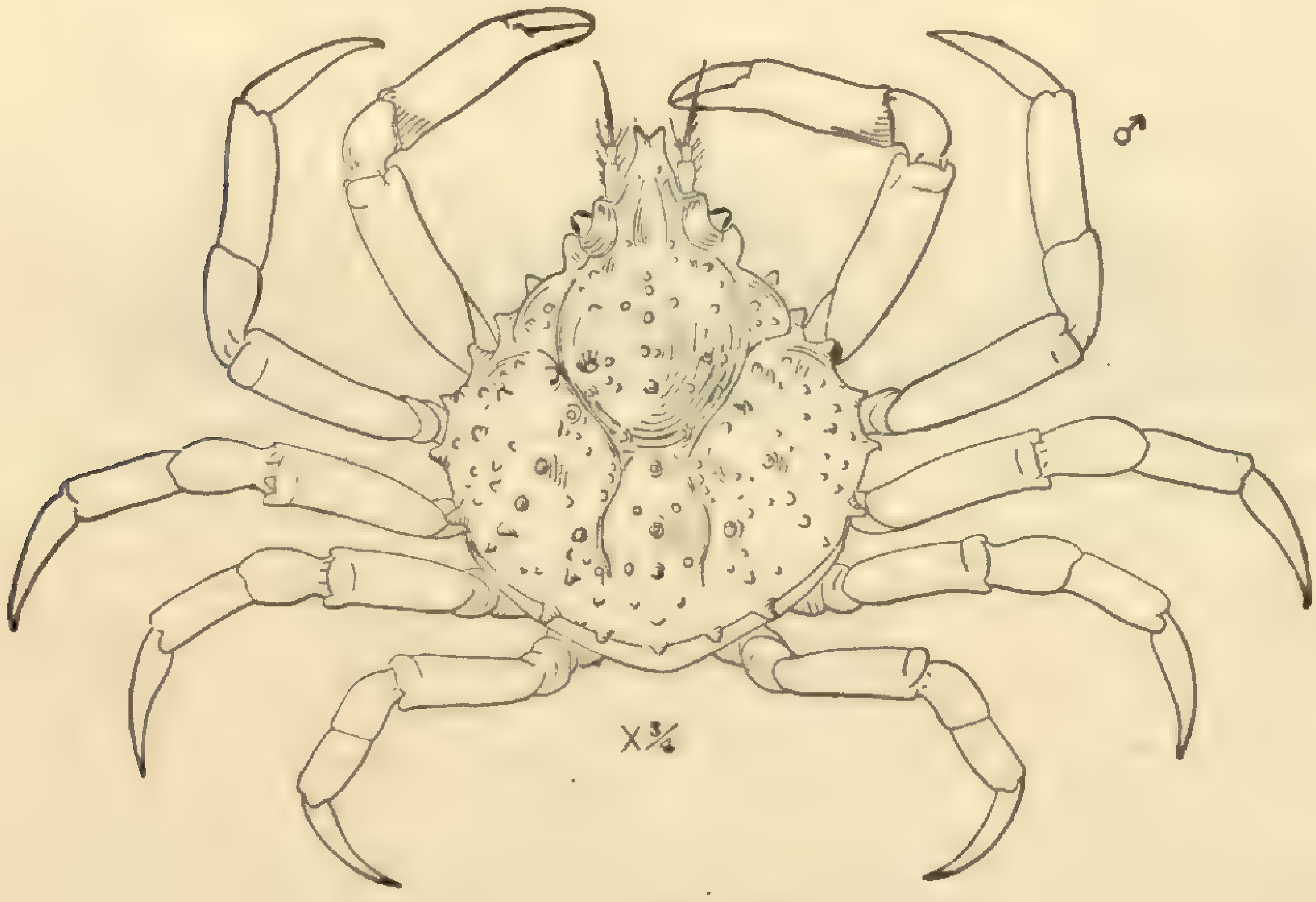

Fig. 10. — Libinia emarginata.

A′. Carapace posteriorly rounded, without lateral angles
L. agonus Stimpson, *G*

Genus Platylambrus Stimpson . *P. serratus* (Milne-Edwards), *M(CH)G*

Genus Solenolambrus Stimpson.

Key to Species.

A. Gastric and cardiac regions with angular ridges
S. decemspinosus Rathbun, *G*

A′. Gastric and cardiac regions without angular ridges
S. tenellus Stimpson, *G*

Genus Cryptopodia Milne-Edwards.

[1] California is given by Owen as the type locality of *Leiolambrus punctatissimus*. As it has not since been recorded north of Lower California, which was known as "California" in 1839, it is inferred that the species does not occur in the United States.

Key to Species.

A. Posterior margin of carapace straight or nearly so. Cardiac region faintly indicated . . . . *C. concava* Stimpson, *G*

A'. Posterior margin of carapace sinuous. Cardiac region protuberant *C. occidentalis* Dana, *PD*

Genus Heterocrypta Stimpson . . . . *H. granulata* (Gibbes), *SGM*

Tribe Oxystomata or Leucosoidea.

Carapace with the antero-lateral margins arcuate or orbiculate; sometimes subglobose or more or less oblong, with subparallel margins. Epistome much reduced. Buccal frame more or less triangular, produced and narrowed forward, with the margins anteriorly convergent. Six to nine

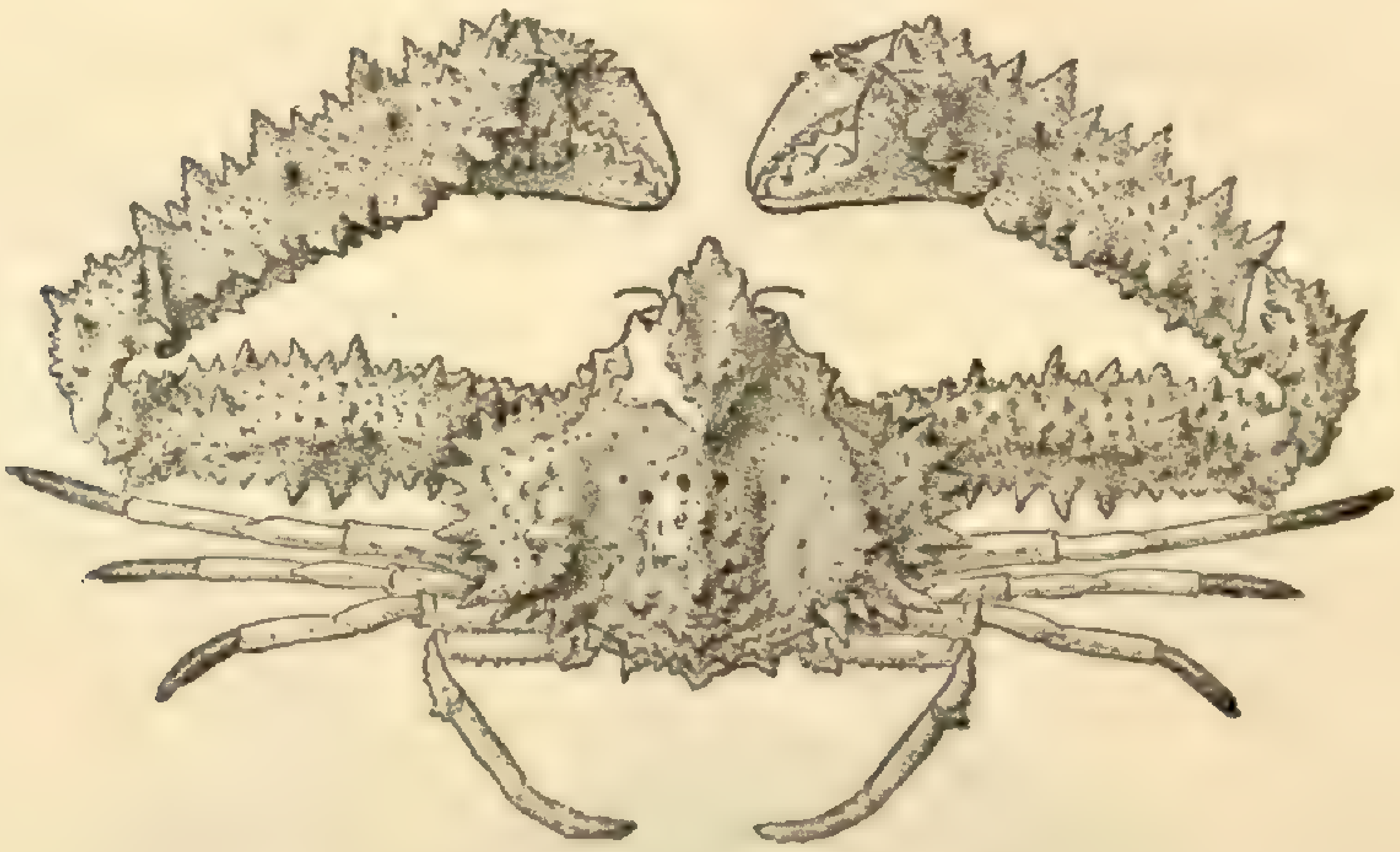

Fig. 11. — Lambrus pourtalesii.

pairs of branchiæ. Efferent channels opening at the middle of the endostome, which is produced forwards. The afferent channels open either behind the pterygostomian regions and in front of the chelipeds, or at the antero-lateral angles of the palate. First antennæ folded longitudinally or obliquely. The genital organs of the male are exserted, either from the bases of the fifth pair of legs, or from the surface of the sternal plastron.

Key to the Families of the Tribe Oxystomata.

A. Legs normal in size and position.

B. Maxillipeds not closing the buccal cavern; their palp always exposed . . . Calappidæ Milne-Edwards, de Haan, White

B'. Maxillipeds closing the buccal cavern; the palp hidden.

C. Afferent branchial openings in front of the bases of the chelipeds . . . . Matutidæ M'Leay

C'. Afferent branchial openings on either side of the endostome Leucosiidæ Leach

A'. Last two pairs of legs much reduced in size, and having a peculiar position in the dorsal plane of the body
Dorippidæ Milne-Edwards, White

Key to the Genera of the Family Calappidæ.

A. Antero-lateral margin continuous with the postero-lateral.
  B. Carapace broadest in its posterior half . . . . Calappa
  B'. Carapace broadest in its anterior half . . . . . Acanthocarpus
A'. Antero- and postero-lateral margins meeting at an angle armed with a stout spine . . . . Platymera

The Species of Calappidæ.

Genus Calappa Fabricius.

Key to Species.

A. Teeth of the posterior margin of the carapace broad and shallow
C. flammea (Herbst), *MSG*
A'. Median pair of teeth of the posterior margin long and slender
C. sulcata Rathbun, *M(CH)G*

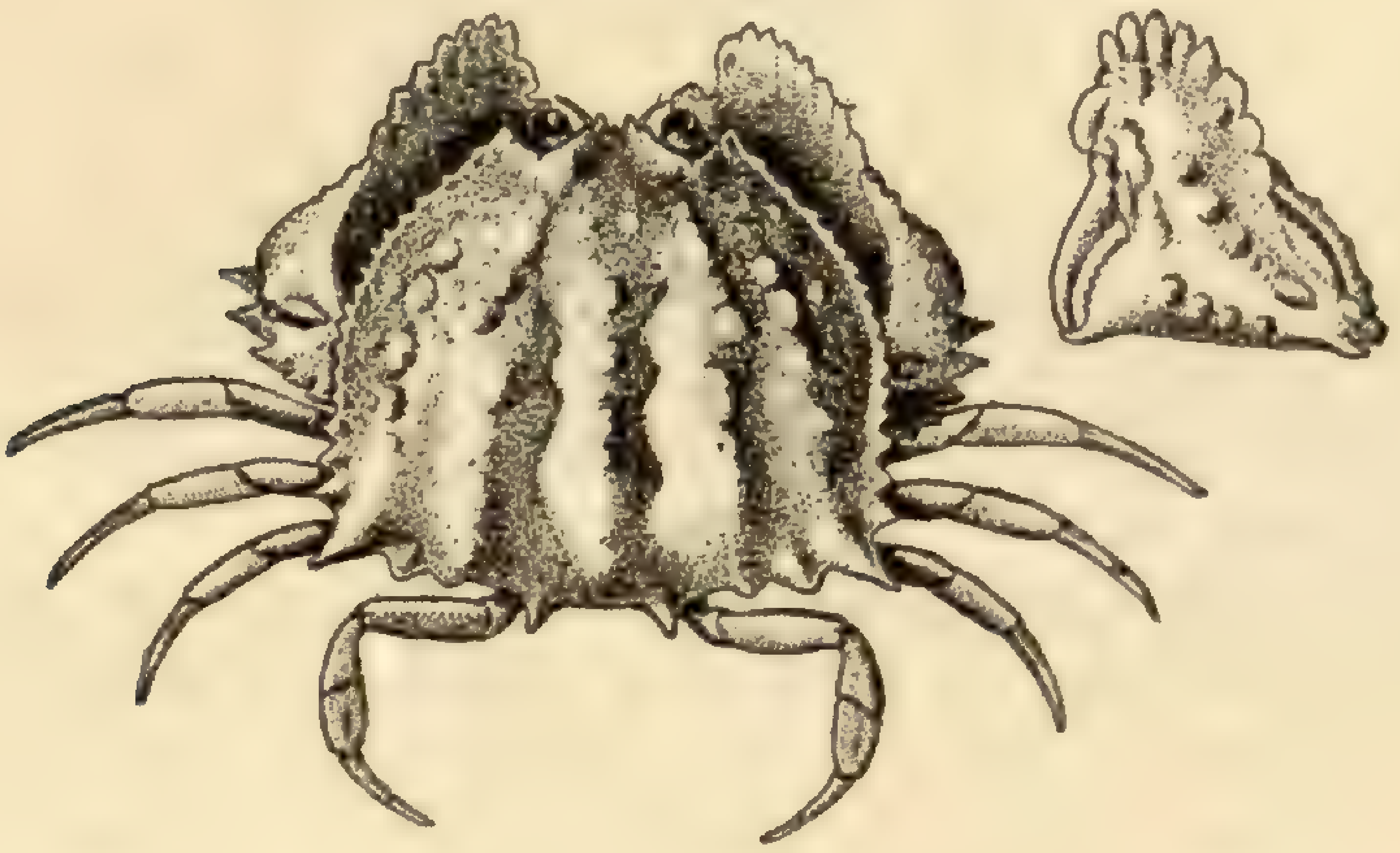

Fig. 12. — Calappa sulcata.

Genus Acanthocarpus Stimpson . . . . *A. alexandri* Stimpson, *MG*
Genus Platymera Milne-Edwards . *P. gaudichaudii* Milne-Edwards, *PD*

Key to the Genera of the Family Matutidæ.

A. Carapace much broader than long; front not produced; surface evenly convex . . . . Hepatus
A'. Carapace nearly as long as broad; front considerably produced; surface very uneven, nodulose . . . . Osachila

The Species of Matutidæ.

Genus Hepatus Latreille.

Key to Species.

A. Carapace marked with large patches of color, margined by darker lines. Length of penultimate segment of abdomen of male two-thirds its proximal width . . . *H. epheliticus* (Linnæus), *MSG*

A′. Carapace marked with transverse lines of small, dark spots. Length of penultimate segment of abdomen of male three-fourths its proximal width . . . . *H. princeps* (Herbst), *S*

Genus Osachila Stimpson . . . . *O. tuberosa* Stimpson, *G*

Key to the Genera of the Family Leucosiidæ.

A. Merus of external maxillipeds more than half the length of the ischium measured along the inner border. Fingers stout, gradually narrowing from base to tip.

- *B*. Little or no space between the edge of the floor of the orbit and the free edge of the buccal cavern.
  - *C*. Intestinal region without a spine. Merus of external maxillipeds nearly as long as the ischium measured along the inner border . . . . Philyra
  - *C′*. Intestinal region with a long spine. Merus of external maxillipeds much shorter than the ischium measured along the inner border . . . . Persephona
- *B′*. A considerable space between the edge of the lower wall of the orbit and the free edge of the buccal cavern.
  - *C*. Carapace almost circular and globular . . . . Randallia
  - *C′*. Carapace polygonal; surface very uneven . . . Lithadia

A′. Merus of external maxillipeds half or less than half the length of the ischium measured along the inner border. Fingers slender, almost of the same diameter from base to near tip.

- *B*. Fingers moving in a vertical plane. Pterygostomian channels projecting considerably beyond the orbits . . . Iliacantha
- *B′*. Fingers moving in a horizontal plane. Pterygostomian channels not projecting beyond the orbits . . . . Myropsis

The Species of Leucosiidæ.

Genus Philyra Leach . . . . *P. pisum* de Haan, *P*

Genus Persephona Leach . . . . *P. punctata* (Linnæus), *M(CH)SG*

Genus Randallia Stimpson . . . . *R. ornata* (Randall), *PD*

Genus Lithadia Bell.

Key to Species.

A. A narrow bridge between two cavities connects the cardiac and branchial regions . . . . *L. pontifera* Stimpson, *M*(*CH*)

A′. No bridge connects the cardiac and branchial regions.

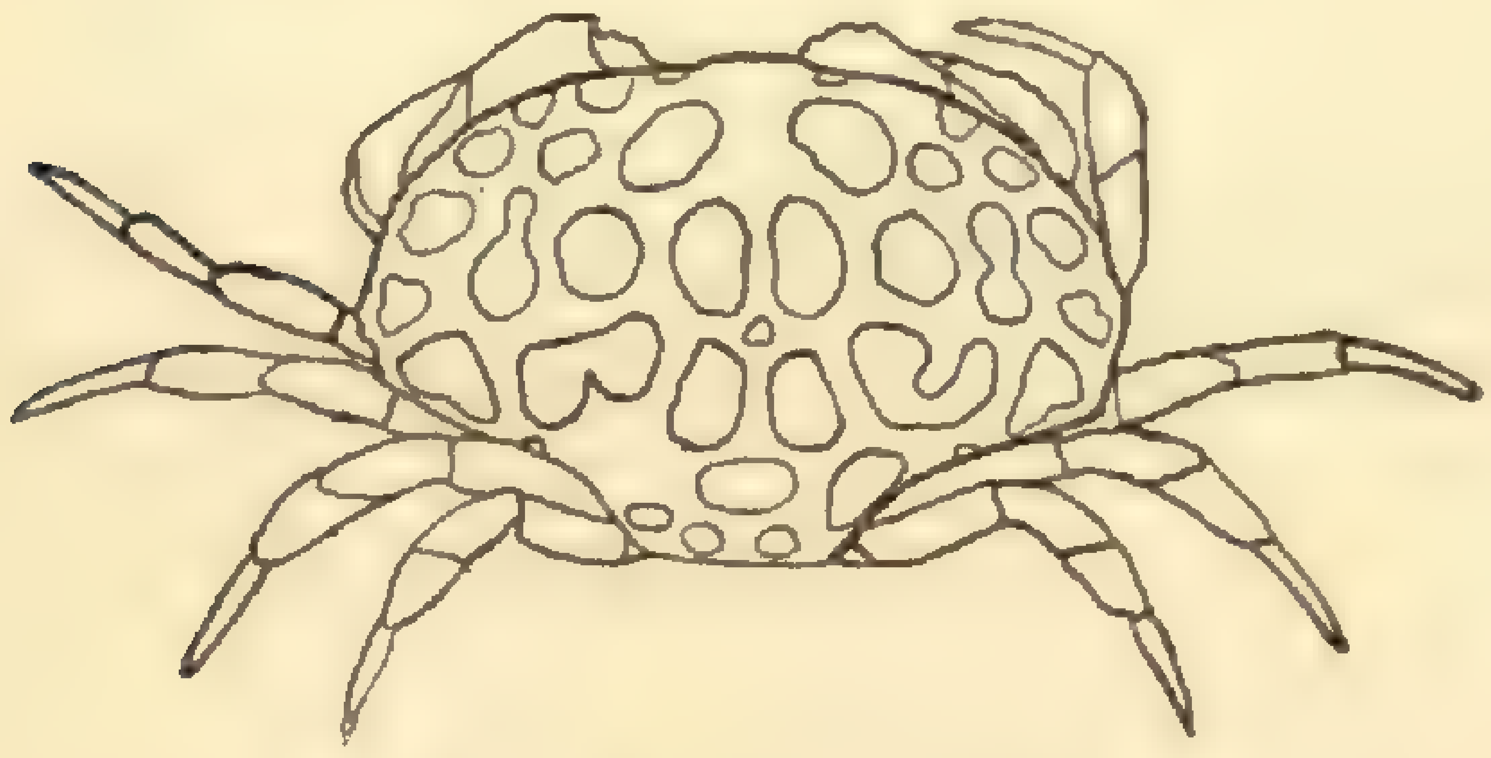

FIG. 13. — Hepatus epheliticus.

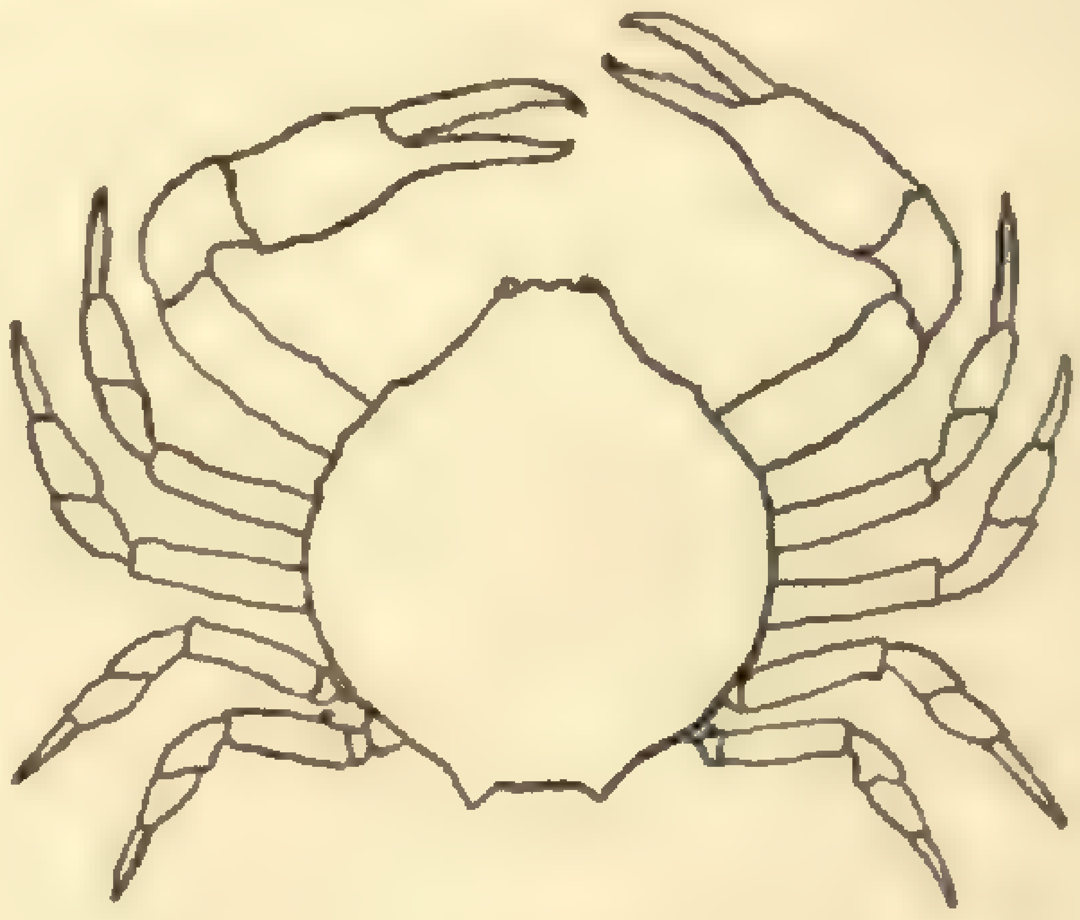

FIG. 14. — Randallia ornata.

B. A transverse ridge between the large branchial protuberance and the lateral margin . . . . *L. cariosa* Stimpson, *M*(*CH*)*G*

B′. A small circular protuberance between the large branchial protuberance and the lateral margin . *L. cadaverosa* Stimpson, *G*

Genus Iliacantha Stimpson . . . . *I. subglobosa* Stimpson, *M*(*CH*)*G*

Genus Myropsis Stimpson . . . . . *M. quinquespinosa* Stimpson, *G*

KEY TO THE GENERA OF THE FAMILY DORIPPIDÆ.

A. The external maxillipeds leave all the anterior part of the buccal cavern uncovered . . . . Ethusa

A′. The external maxillipeds cover the buccal cavern . . Cyclodorippe

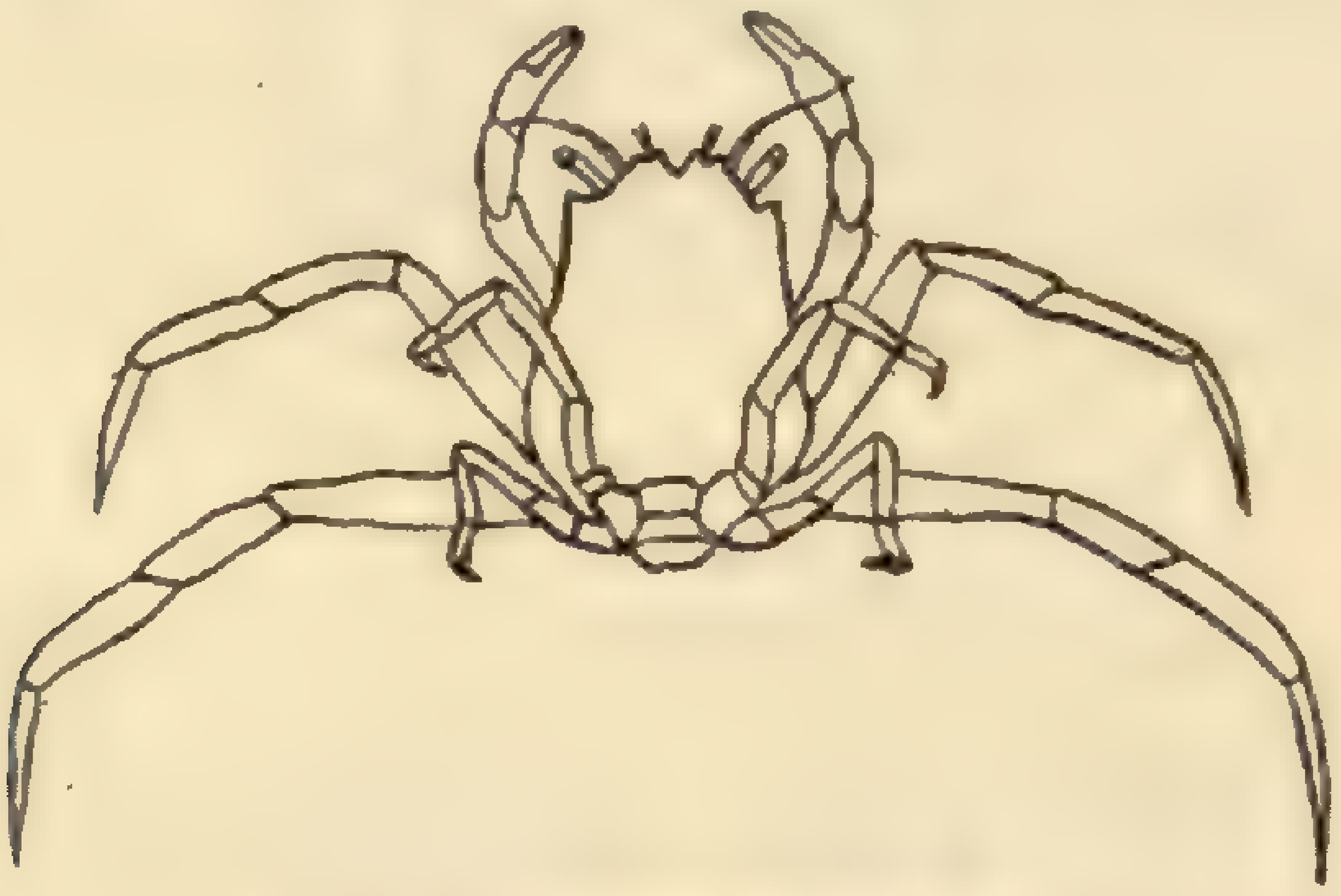

FIG. 15. — Ethusa mascarone.

THE SPECIES OF DORIPPIDÆ.

Genus Ethusa Roux.

Key to Species.

A. Eyestalks long, extending laterally beyond the postorbital spine *E. mascarone americana* (A. Milne-Edwards), *M*(*CH*)*G*

A′. Eyestalks short, directed forward.

B. Dactyli of second and third pairs of legs broad, flattened
E. microphthalma Smith, *M*

B'. Dactyli of second and third pairs of legs slender, not flattened
E. tenuipes Rathbun, *G*

Genus Cyclodorippe A. Milne-Edwards.

Key to Species.

A. Carapace convex. No hepatic tooth *C. nitida* A. Milne-Edwards,[1] *D*

A'. Carapace flattened. A hepatic tooth . . . *C. plana* (*sp. nov.*), *G*

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REVIEWS OF RECENT LITERATURE.

ANTHROPOLOGY.

The Races of Man. — A new treatise upon anthropology, by Dr. Joseph Deniker, of the Natural History Museum, Paris, has been published by the Scribners in "The Contemporary Science Series." It is a very compact little volume of six hundred pages, containing many carefully selected illustrations for the elucidation of the text and numerous bibliographic notes. Comparison with somewhat similar compendiums shows how rapidly anthropology has developed since the publication of Oscar Peschel's *Races of Man* and Fr. Muller's *Allgemeine Ethnographie* a quarter of a century ago. Deniker has treated his subject more fully than the philosophic Brinton in *Races and Peoples;* he has given less space to palethnography than has Professor Keane in *Man, Past and Present.*

Dr. Deniker is inclined to adopt the classification of the anthropologic sciences advocated by Professor Brinton. We commend his views concerning ethnology to the attention of those who fear that this growing young science will seek to absorb all cognate fields of research. "This latter science should concern itself with human societies under all their aspects; but as history, political economy, etc., have already taken possession of the study of civilized peoples, there only remain for it the peoples without a history, or those who have not been adequately treated by historians. However, there is a convergence of characters in mankind, and we find even to-day the trace of savagery in the most civilized peoples. Ethnical facts must not, then, be considered separately. We must compare them either among different peoples, or, down the course of the ages, in the same people, without concerning ourselves with the degree of actual civilization attained."

Three chapters are devoted to "Somatic Characters," dealing successively with the "distinctive characters of man and apes," "distinctive morphological characters of human races," "physiological characters," and "psychological and pathological characters." The principal physical criteria of race — head-form, pigmentation, stature, and hair — receive special attention, and a number of new statistical

tables are furnished in the appendixes to the volume. The hair is given particular prominence in the classification of races according to morphological characters. Confidence is expressed in the ability of Europeans to colonize the Tropics, though little evidence is adduced in support of the opinion. For the first time, we believe, in a general work attention is directed to the nervous susceptibility of savages, which some students of primitive culture regard as an important factor in the development of religion.

"Ethnic Characters," including language, the arts, religion, the family, and social life, are treated in four chapters that seem all too brief to the serious student. Indeed, the entire volume reminds the reader of Tony Weller's comment upon brevity in letter writing.

Half the book is devoted to Races and Peoples. Dr. Deniker modifies somewhat his classification of the races of mankind in general, published in 1889, and now divides the species into twenty-nine races, which in turn are separated into seventeen groups, by taking into account other characters than somatic alone. The ancient inhabitants of Europe are passed over with but brief mention; the Aryan question is dismissed as unanswerable and no longer of any consequence in anthropology. His well-known scheme of classification of the present races of Europe into six primary and four secondary races is given in briefer form than in previously published papers of the Anthropological Society of Paris. The few paragraphs upon the archæology of Asia show that the subject is becoming better known and sheds light upon the ancient history of Europe. The complete account of the migrations of Asiatic tribes within historic times cannot yet be written. So also we can only discern in a general way the elements furnished by the eleven races into which the peoples of the continent are divided.

Dr. Deniker accepts quaternary man in North America as established by the discoveries at Trenton, Little Falls, Minnesota, etc. The mounds of North America are ascribed to the Indians. The modern tribes are considered by ethnographic provinces rather than by groups based upon somatic characters or ethnic traits.

The author is certainly correct in his belief "that even professional anthropologists will be able to consult" this work "profitably." While ethnic maps would have added much to the value of the book, and though there are statements of fact and deductions susceptible to criticism, yet it presents a masterly summary of an extensive and intricate subject.

FRANK RUSSELL.

ZOÖLOGY.

The White-Fish of Lake Chapala. — In 1879 the writer secured a single specimen of the famous "Pescado Blanco," a delicious food fish found in Lake Chapala, in Mexico. This was described under the name of *Chirostoma estor.* It is an atherinoid fish (Silversides or Pesce-rey), translucent and delicate in substance and about a foot in length. Last winter Mr. J. O. Snyder and the writer visited this lake and obtained a very large collection of the "Pescado Blanco." On critically examining it we were surprised to find that the material contained six distinct species, similar in color and appearance but differing in technical characters, and not one of them identical with the original *Chirostoma estor.* Two of these six species have been lately described by Dr. G. A. Boulenger from specimens taken by Mr. A. C. Buller, under the names of *Chirostoma lucius* and *Chirostoma sphyræna* (*Ann. Mag. Nat. Hist.*, 1900, pp. 54, 55). These names have priority over those printed but not yet published by Jordan and Snyder. D. S. J.

Evermann on Species and Subspecies. — In *Science* for March 23, Dr. B. W. Evermann gives a very sane and accurate account of the formation of species and subspecies, using two species of darters in Lake Maxinkuckee as illustrations. He closes with these words: "We sometimes hear the remark that 'systematists often go too far and describe as new species or subspecies forms which differ but slightly from known forms, that they give specific or subspecific value to differences which are due merely to slight differences in environment.' This misses the whole point. What produces species and subspecies except slight differences in environment with greater or less geographical isolation? And when we see these differences why should we refuse to admit their existence or their meaning?"

D. S. J.

Smith on the Fishes of Woods Holl. — In *Science* for December 15, Dr. H. M. Smith adds a number of tropical species to the list of fishes known from Woods Holl, raising the number of species to 240, the largest recorded from any Atlantic locality north of Key West. The species not hitherto recorded from north of Carolina are the following: *Muræna retifera*, *Apogon maculatus*, *Epinephelus adscensionis*, *Garrupa nigrita*, *Mycteroperca bonace*, *Mycteroperca inter-*

stitialis (?), *Eupomaceutrus leucostictus*, *Teuthis hepatus*, *Teuthis cæruleus*, *Teuthis bahianus*, *Lactophrys triqueter*, *Chilomycterus antillarum*, *Scorpæna plumieri*, and *Scorpæna grandicornis*. All of these are evidently species borne northward in the Gulf Stream. D. S. J.

Eigenmann on Blind Vertebrates. — In *Science* for March 30, Dr. Carl H. Eigenmann publishes his address as President of the Indiana Academy of Sciences on "Degeneration of the Eyes of the Cold-Blooded Vertebrates of the North-American Caves." In this he discusses in detail the eye degeneration of the cave salamanders and cave blind-fishes. He concludes that "degeneration has not proceeded in the reverse order of development. Rather the older normal stages of ontogenetic development have been modified into the more recent phyletic stages through which the eye has passed. The adult degenerate eye is not an arrested ontogenetic stage of development but a new adaptation, and there is an attempt in ontogeny to reach the degenerate adult condition in the most direct way possible." D. S. J.

Microbdella biannulata. — Under this name J. Percy Moore[1] describes a remarkable leech of the family Glossiphonidæ, recently discovered by him in the mountain region of North Carolina, attached to the body of the salamander *Desmognathus fusca*. Leeches of the family named have somites ordinarily composed each of three rings about equal in width. In Microbdella, however, a typical somite is biannulate dorsally, uniannulate ventrally. The two rings into which the somite is divided on the dorsal surface are not of equal width, the anterior one being much broader and corresponding evidently with the first and second rings of a typical somite of Glossiphonia. The segmental sense organs of the dorsal surface are situated in the posterior half of the broad anterior ring. The single broad ring of which the somite is composed on the ventral surface is clearly equivalent to all three rings of a somite of Glossiphonia.

Moore's discovery shows the correctness of two general conclusions recently announced by W. E. Castle[2] as a result of studies made chiefly on Glossiphonia:

1. The sensory ring of the leech somite is the *middle*, not the anterior ring of the somite, as has been generally assumed hitherto.

[1] *Proc. Acad. Nat. Sci. Phila.*, April, 1900.

[2] *Proc. Amer. Acad. Arts and Sci.*, February, 1900.

2. A biannulate condition of the leech somite has probably preceded phylogenetically the triannulate condition; still earlier the somite was probably uniannulate, as in the chætopods. The simple uniannulate somite became biannulate by the separation of a narrow posterior ring from the rest of the somite; the triannulate condition was reached by the separation of a narrow ring at the anterior end of the somite, the sensillæ remaining on the middle ring.

These conclusions have been reached quite independently by Moore, who presents incontrovertible evidence in their support. He further expresses the opinion that the shorter somites commonly found at either end of the body of a leech are not, as they are usually regarded, "abbreviated" somites once multiannulate, but rather represent "stages of development arrested or in progress" from the uniannulate to the multiannulate condition.

The number of somites in the body of Microbdella is probably the same as in Glossiphonia (Clepsine) and Herpobdella (Nephelis), though Moore finds some evidence, not to his mind conclusive, of the existence of an additional somite at the anterior end of the body.

Locomotion of Solenomya. — Solenomya and its relatives show three methods of locomotion which have been studied by G. A. Drew.[1] The first is well represented in Yoldia. This clam possesses a spatula-like foot split into two plates at its distal end. The animal drives this foot into the mud, with the distal flaps held together. These are then expanded and serve as an anchor so that the contraction of the longitudinal muscles of the foot draws the animal through the mud to the place where the foot is anchored. There is no reason to suppose that these mollusks creep about on the expanded foot as snails do. The second method of locomotion, that of leaping, is seen in Solenomya, and especially in Yoldia. When the animal rests sidewise on a smooth surface, the foot is protruded and turned under the lower valve. If the foot is then suddenly contracted, the shell may be thrown end for end some inches. The third method of locomotion is that of swimming. This is accomplished by the vigorous ejection of water from the mantle cavity. The mantle lobes are united except at their anterior and posterior ends. By the separation of the valves, through the action of the elastic ligament, the mantle chamber is filled with water. The anterior opening is then closed by the foot, and by a vigorous

[1] Drew, G. A. Locomotion in Solenomya and its Relatives, *Anat. Anz.*, Bd. xvii, pp. 257–266, 1900.

contraction of the mantle musculature the water is expelled through the posterior opening, thus driving the body of the animal forwards. By a succession of such jets the animal may swim some feet before settling. P.

Ear Bones. — The ear bones of vertebrates have undergone a careful comparative examination at the hands of J. S. Kingsley.[1] In urodeles and cœcilians, where no tympanum exists, a stapes, which develops independently of the otic capsule, is the only element present. In the anura the space between the otic capsule and the tympanum is spanned by three elements, the stapes, the pseudoperculum, and the extracolumella, which collectively constitute the so-called columella of this group. It is important to observe that the intermediate piece, the pseudoperculum, is developed from the posterior wall of the tympanic cavity. In lizards the chain of ear bones consists of only two, the stapes and the extracolumella. Of the three ear bones in the pig the malleus is composed of three parts, a manubrium corresponding to the extracolumella of lower forms, a body representing the articulare, and a membrane bone forming at least a part of the *processus gracilis.* The stapes of the pig is homologous with the stapes of lower vertebrates. The incus which unites malleus and stapes cannot correspond to the pseudoperculum of lower vertebrates, because it develops from the anterior instead of the posterior wall of the tympanic cavity. As this position is that occupied by the quadrate, the incus is believed to be homologous with this bone. It will thus be seen that while the distal and proximal ends of the chain of ear bones in mammals and in lower vertebrates are homologous, the intermediate members are not, being the posterior pseudoperculum in amphibia and the anterior incus (quadrate) in mammals. P.

Otocysts of the Heteropods. — Ilyin[2] has experimented upon Carinaria and Pterotrachea with the view of determining the physiological value of the otocysts in these mollusks. The otocysts are apparently stimulated not as auditory organs but as tactile organs. When both organs are removed, the animal is unable to keep itself correctly oriented and swims in circles. The presence or absence

[1] Kingsley, J. S. The Ossicula Auditus, *Tufts College Studies*, No. 6. (Scientific Series.) 1900.

[2] Ilyin, P. Das Gehörbläschen als Gleichgewichtsorgan bei den Pterotracheidæ, *Centralbl. f. Phys.*, Bd. xiii, pp. 691–694, 1900.

of the eyes does not alter this reaction, so that orientation is not accomplished in these forms by the eye, as in many other animals. The loss of one otocyst does not affect the animal's movements, the remaining one being sufficient to keep it normally oriented. P.

Capillaries and Sinusoids. — C. S. Minot[1] draws attention to the fact that in the vertebrates blood vessels are connected not only by capillaries but also by irregular, minute spaces, for which he proposes the name "Sinusoids." The walls of a sinusoid, like those of a capillary, are formed from a single layer of endothelial cells, but the capillary wall has the form of a tubule, while that of the sinusoid follows the irregular surfaces of the tissue spaces in which it lies; capillaries are tubules, but sinusoids are irregular, branching systems of spaces. Sinusoids form the main blood channels in the pronephros, mesonephros, liver, heart, supra-renal capsules, parathyroid glands, carotid glands (probably), and coccygeal glands. P.

Villi of the Mammalian Intestine. — The development of the villi in the intestine of man and of the pig has been investigated by J. M. Berry.[2] The inner surface in young embryos is at first smooth, but afterwards becomes thrown up into longitudinal folds, such as are found permanently in many of the lower vertebrates. These folds increase in size and then break up into rows of villi. After the first villi become fully developed, new ones are added to the intestinal surface, so that fully developed villi and forming villi may be found side by side, the number of the villi thus increasing with increase of age. P.

Notes. — Dr. Kishinouye has described (*Proc. U. S. Nat. Mus.*, Vol. XXII, p. 125) a new species of stalked jellyfish, *Haliclystus stejnegeri.* This genus has thus far been represented by three Atlantic species. The new form comes from the Commander Islands in the Pacific.

The distome genus Clinostomum, founded in 1856 by Leidy, has been brought forward again by Braun (*Zool. Anz.*, Bd. XXII,

[1] Minot, C. S. On a hitherto unrecognized Form of Blood Circulation without Capillaries in the Organs of Vertebrates, *Proc. Boston Soc. Nat. Hist.*, vol. xxix, pp. 185–215, 1900.

[2] Berry, J. M. On the Development of the Villi of the Human Intestine, *Anat. Anz.*, Bd. xvii, pp. 242–249, 1900.

pp. 484–488, 489–493), who finds in it a natural group, clearly and sufficiently characterized by the anterior end and the genital and excretory systems to be distinguished from all other distomes. He gives a résumé of the known species and adds six new. Almost simultaneously with this has appeared an excellent description of an American species by W. G. MacCallum (*Journ. of Morph.*, Vol. XV, pp. 697–710, 1 plate).

The structure and biology of *Oxyuris curvula* have been studied by H. Ehlers (*Arch. f. Naturges.*, 1899; 26 pp., 2 plates). He confirms the previous opinion that the variably long tail of the female is a mark of advancing age and not a specific character, and finds that, contrary to the ordinarily received view, this species is of pathologic importance. Experimentation showed that direct infection is possible, if not general, and that the period of development covers about three months.

Towards the analysis of the old group of distomes Stossich has recently contributed a study on the dismemberment of the genus Brachycœlium Duj. (*Boll. Soc. Adr. Sci. Nat.*, Trieste, Vol. XIX, pp. 7–10), and a second paper on the partition of the genus Echinostomum Duj. (*ib.*, pp. 11–16).

In some biological observations on Galeodes and Buthus, E. Lönnberg (*Ofv. Kgl. Vet.-Akad. Förh.*, 1899, No. 10, pp. 277–284) records that the poison of the latter was not strong enough to kill the former, and that the belief in the self-destruction of the scorpion when surrounded by fire rests on erroneous observation. In Galeodes it is the mechanical power of the jaws only that renders it dangerous, and this is not sufficient to pierce the human skin.

Another paper on the fishes of the Caucasus, based on Dr. Radde's collections, is published in German and Russian by Dr. S. Kamensky, assistant in zoölogy in Charcow. Numerous new species of Barbus (Barbel) are described and figured.

The fourth part of Boulenger's admirable report on the fishes of the Congo is now published. It includes Cleopaidæ, Mormyridæ, etc., and the descriptions are accompanied by excellent plates.

NEWS.

THE German Society of Naturforscher und Artze meets this year at Aachen from the 17th to the 21st of September.

Mr. Dean C. Worcester has resigned his position as assistant professor of zoölogy in Michigan University, to accept his appointment as member of the new Philippine Commission.

Dr. Th. M. Fries, professor of botany in the University of Upsala, has retired.

The British Association for the Advancement of Science meets this year at Bradford, beginning September 5, under the presidency of Sir William Turner.

An International Congress of General Botany is to be held in Paris from the 1st to the 10th of next October. The Congress will be under the auspices of the government in connection with the Exposition.

The Biological Laboratory of the Brooklyn Institute of Arts and Sciences at Cold Spring Harbor, Long Island, announces the eleventh season of summer instruction in natural history.

Professor C. B. Davenport will have for his staff: Professor H. S. Pratt, comparative anatomy; Professor C. P. Sigerfoos, embryology; S. R. Williams, zoölogy; Gertrude C. Davenport and W. L. Tower, microscopic methods; Dr. D. S. Johnson, cryptogamic botany; Dr. H. C. Cowles, phanerogamic botany; W. C. Coker, botany; Professor N. S. Davis, bacteriology; Dr. H. A. Kelly, nature study; W. H. C. Pynchon, photography. The laboratory will be open from July 2 to August 25. Correspondence should be addressed to Professor Franklin Hooper, 502 Fulton Street, Brooklyn, or to Professor C. B. Davenport, University of Chicago.

The Ohio State University announces a course of study for the summer of 1900 at its Lake Laboratory, at Sandusky, Lake Erie. Four courses are offered in zoölogy and three courses in botany. The staff consists of Professor H. Osborn, zoölogy and entomology; Assistant Professor Jas. S. Hine, entomology; F. L. Landacre, zoölogy; Professor W. A. Kellerman, botany; Assistant Professor

J. H. Schaffner, botany. The school will open on July 2 and will continue for eight weeks. Correspondence should be addressed to Professor Herbert Osborn, Ohio State University, Columbus, Ohio.

The Marine Biological Laboratory at Woods Holl announces a special course in nature study designed to meet the needs of teachers. The course will commence on July 5 and extend over a period of six weeks. The courses of instruction in botany will include cryptogamic botany by Dr. Davis and Mr. Moore, plant physiology by Dr. R. H. True, plant cytology and micro-technique by Dr. Davis. Correspondence should be addressed to Professor C. O. Whitman, University of Chicago, or to Professor Ulric Dahlgren, Princeton University.

We are indebted to the May issue of the *Review of Reviews* for the following announcements:

Mr. Albert L. Arey announces the eleventh season of his natural-science camp for boys at Canandaigua, N. Y. Instruction is given in the subjects of biology, entomology, taxidermy, and photography.

The Rhode Island Summer School for Nature Study will hold its second session on July 5–20, at Kingston, R. I. Tuition is free to teachers in the schools of Rhode Island.

Beloit College, Wisconsin, will hold a summer school on Madeline Island, Lake Superior, from July 26 to August 30.

A school of applied agriculture and horticulture will be established near New York City, to open in September for study and practical training. Students will have the use of the laboratories and the extensive collection of plants in the museum, the conservatories, and upon the grounds of the New York Botanical Garden. The work will be under the direction of Mr. George T. Powell.

Appointments: Dr. Antonio Baldacci, docent for botany in the University of Bologna. — Dr. Alexander Balint, docent for zoölogy in the University of Klausenburg. — Dr. C. R. Bardeen, professor of anatomy in the University of California. — Dr. Llewellys Barker, of Johns Hopkins, professor of anatomy and neurology in the University of Chicago. — Dr. A. N. Berlese, professor of botany in the University of Sassari, Sardinia. — Dr. Albrecht Bethe, docent for physiology in the University of Strassburg. — Dr. H. Böckh, professor of mineralogy and paleontology in the Akademie in Ṡchemnitz, Hungary. — Dr. Hermann Braus, professor extraordinary of anatomy in the University of Würzburg. — Dr . O. Brefeld, professor of

botany in the University of Breslau. — Dr. Willy Bruhns, professor extraordinary of mineralogy and petrography in the University of Strassburg. — Dr. O. Burger of Göttingen, professor of zoölogy in the University of Santiago, and director of the zoölogical section of the National Museum. — Dr. W. E. Castle, instructor in zoölogy in Harvard University. — Howard Emlyn Davies, assistant in bacteriology in the University of Chicago. — Dr. Gustav Fritsch, honorary professor of physiology in the University of Berlin. — Dr. Fünfstück, professor of botany in the Stuttgart Polytechnical School. — Mr. A. W. Grabau, instructor in geology in the Rensselaer Polytechnic Institute at Troy, N. Y. — Frederick O. Grover, professor of botany in Oberlin College. — W. F. E. Gurley, associate curator of paleontology in the University of Chicago. — Dr. J. B. Hatcher, of Princeton, curator of vertebrate paleontology in the Carnegie Museum at Pittsburg. — Dr. E. von Hibler, docent for anatomy in the University of Innsbruck. — W. H. Hobbs, professor of mineralogy and petrography in the University of Wisconsin. — Dr. E. O. Jordan, associate professor of bacteriology in the University of Chicago. — Dr. F. R. Kjellmann, professor of botany in the University of Upsala. — Eduard Lampe, conservator of the Natural History Museum at Wiesbaden. — Dr. Frank R. Lillie, of Vassar College, assistant professor of zoölogy in the University of Chicago. — Dr. Jacques Loeb, professor of physiology in the University of Chicago. — Dr. Karl Mez, professor extraordinary of botany in the University of Halle. — Dr. Luigi Montemartini, docent for botany in the University of Pavia. — Dr. A. Osann, professor extraordinary of geology in the University of Basel. — Dr. F. Sandor, docent for mineralogy in the University at Agram, Austria. — Dr. von Schmidt, docent for histology and embryology in the University of Jena. — Dr. Max Semper, docent for paleontology in the technical school at Aachen. — Dr. Angelo Senna, docent for zoölogy and comparative anatomy in the Institute for Superior Studies at Florence. — G. Severin, the entomologist, conservator of the Natural History Museum in Brussels. — Dr. Wilson R. Smith, instructor in botany in McMaster University, Toronto. — Dr. Hans Solereder, professor extraordinary of botany in the University of Munich. — Dr. Stahr, docent for anatomy in the University at Breslau. — Dr. A. Steuer, docent for geology in the Darmstadt Technical School. — Dr. Alexander Tornquist, professor extraordinary of geology and paleontology in the University of Strassburg. — John E. Webb, assistant in physiography and biology in the University of Chicago. — Stuart Weller, instructor in geology

in the University of Chicago. — Dr. Gregg Wilson, tutor in zoölogy in Heriott-Watt College, Edinburgh. — Mr. J. B. Woodworth, of Harvard, assistant on the New York Geological Survey. — H. Woods, tutor in paleozoölogy in the University of Cambridge.

Deaths: Émile Blanchard, zoölogist, at Paris. — Mr. Andrew Bolter, entomologist, in Chicago, March 18, aged 80. — John Brooks Bridgman, student of Hymenoptera, at Norwich, England, October 6, aged 63. — W. E. Brooks, ornithologist, at Mount Forest, Ontario, aged 70. — Giovanni Canestrini, professor of zoölogy and comparative anatomy in the University of Padua, February 14. — Edouard Coucke, student of Coleoptera, in Brussels. — Frank Hamilton Cushing, ethnologist, well known for his studies of the Zuñi Indians, April 10, aged 43. — François Decaux, entomologist, in Neuilly. — George Dowker, botanist and geologist, at Ramsgate, England, September 23, aged 71. — Dr. A. Ernst, formerly director of the National Museum at Caracas, Venezuela. — Richard Fereday, student of lepidoptera, at Christchurch, New Zealand, August 30, aged 79. — Hans Bruno Geinitz, the geologist and paleontologist, at Dresden, January 28, aged 86. — Walter Götze, botanist, in German East Africa. — Baron J. C. L. d'Hamonville, ornithologist, near Manonville, France, November 17, aged 69. — F. L. Harvey, professor of natural history in Maine State College and botanist and entomologist to the Maine Experiment Station, by suicide, March 6, aged 50. — Baron Oskar von Loewis, of Menar, at Kudling, Livonia, an ornithologist, Aug. 6, 1899, aged 61. — A. F. Marion, professor of zoölogy in the Faculty of Sciences at Marseilles, January 23, aged 53. — P. Matheron, paleontologist, in Marseilles, Dec. 31, 1899, aged 93. — M. Alphonse Milne-Edwards, the eminent French zoölogist, April 21, aged 64. — Professor St. George Mivart, the well-known zoölogist, in London, April 1, aged 73. — Dr. R. Nasse, geologist, in Berlin, December 2, aged 62. — Dr. Wilhelm von Nathusius, well known for his studies of the shell of birds' eggs in Halle, December 25, aged 78. — Dr. Manuel Paulino d'Oliveira, professor of zoölogy at Coimbra, Portugal, August 25. — Dr. Karl Maria Paul, of the Austrian Geological Survey, in Vienna, February 10. — Dr. Lucien Quélet, mycologist, in Herimoncourt, France. — Mr. George P. Sennet, ornithologist, at Youngstown, Ohio, March 18, aged 59. — Dr. Karl Sommer, student of Lepidoptera in Oberlössnitz, Germany, November 18. — Dr. Wilhelm Zenker, astrophysicist, but earlier a student of arthropods, in Berlin, October 21, aged 70. — Dr. Giovanni Zoja, professor of anatomy in Padua.

NOTE ON CESTODE NOMENCLATURE.

In many of the cestodes there occurs at the beginning of the germ duct an organ, chiefly muscular in structure, which engages the germ cells on their release from the germarium and forwards them into the germ duct. From its characteristic movements in the discharge of this function the organ was well named "Schluckapparat" by Pintner, who made the first extended study of its occurrence and structure. Its presence has been generally recognized by investigators on cestode structure since then, and the term used by Pintner has been widely employed even in French and English papers. The evident disadvantages of such terms as are unpronounceable and unintelligible to students unfamiliar with the German and are furthermore incapable of inflection, serve as my excuse for calling attention to a term in use in the laboratory here to designate this structure, namely, *oöcapt.* Formed on the analogy of Leuckart's generally accepted term "oötype" for a neighboring structure in the reproductive apparatus and conveying the appropriate idea suggested by Pintner, the term "oöcapt" has proved in use both convenient and precise. As it is to be used in papers now being published by some of my students, this explanation is also necessary in order to prevent possible confusion or misunderstanding regarding its origin and meaning.

Henry B. Ward.

The University of Nebraska.

PUBLICATIONS RECEIVED.

(Regular exchanges are not included.)

BÜTSCHLI, O. Untersuchungen über Mikrostrukturen des erstarrten Schwefels nebst Bemerkungen über Sublimation, Ueberschmelzung und Uebersättigung des Schwefels und einiger anderer Körper. Leipzig, Engelmann, 1900. 96 pp., 4to, figures and 4 plates. 11 marks. — CORRENS, C. Untersuchungen über die Vermehrung der Laubmoose. xxiv, 472 pp., 8vo, 187 figs. 15 marks.— HABERLANDT, M. Ethnology. Translated from the German by J. H. Loewe. London, The Macmillan Company, 1900. 169 pp., 16mo, 56 figs. 40 cents. — HILLEBRAND, W. F. Praktische Anleitung zur Analyse der Silikagesteine. Nebst einer Einleitung enthaltend einige Prinzipien der Petrographisch-Chemischen Forschung von F. W. Clarke und W. F. Hillebrand. Uebersetzt und für den Gebrauch in Laboratorien herausgegeben von Dr. E. Zschimer. Leipzig, Engelmann, 1899. 86 pp., 8vo. 2 marks. — LANKESTER, E. RAY. A Treatise on Zoölogy. Part III, The Echinodermata. By F. A. Bather, J. W. Gregory, and E. S. Goodrich. London, Adam and Chas. Black, 1900. vi, 344 pp., 8vo, 220 figs. 15/. — NICHOLSON, H. H., and AVERY, S. Laboratory Exercises, with Outlines for the Study of Chemistry. New York, Henry Holt & Co., 1899. x, 134 pp., 8vo, 26 figs. 60 cents. — PLATE, L. Ueber Bedeutung und Tragweite des Darwin'schen Selectionsprincips. Leipzig, Engelmann, 1900. 153 pp., 8vo. 2 marks. — PRANTL. Lehrbuch der Botanik herausgegeben und neu bearbeitet von Dr. Ferdinand Pax. Leipzig, Engelmann, 1900. viii, 455 pp., 8vo, 414 figs. 4.60 marks. — WAGNER, Ad. Studien und Skizzen aus Naturwissenschaft und Philosophie. III. Ueber das Problem der "angeborenen (apriorischen) Vorstellungen." Berlin, Bornträger, 1900. 77 pp., 8vo. — WILLEY, ARTHUR. Zoölogical Results based on Material from New Britain, New Guinea, Loyalty Islands, and elsewhere, etc. Part III contains Gadow, H., Orthogenetic Variation in the Shells of Chelonia; Willey, Arthur, Enteropneusta from the South Pacific, with Notes on the West Indian Species; Shipley, A. E., On a Collection of Echiurids from the Loyalty Islands, etc. Cambridge, University Press, 1899. pp. 207–356. 10 plates. 12/6.

FARRINGTON, O. C. New Mineral Occurrences and Crystal Forms of Calcite from Joplin. *Missouri Field Col. Mus.* Geological Series, Vol. i, No. 7, pp. 221–241, figures and 3 plates. — GANE, H. S. Some Neocene Corals of the United States. *Proc. U.S. Nat. Mus.* Vol. xxii, pp. 179–198, 1 plate. — GREENE, CHAS. W. Contributions to the Physiology of the California Hagfish *Polistotrema stouti*. I. The Anatomy and Physiology of the Caudal Heart. *Amer. Journ. of Phys.* Vol. iii, No. 8. — KERR, J. G. The External Features in the Development of *Lepidosiren paradoxa* Fritz. *Phil. Trans.* Vol. cxcii, pp. 299–330, 5 plates. — MILLEPAUGH, C. F. Plantæ Utowanæ. Plants collected in Bermuda, Porto Rico, etc. The Antillean Cruise of the Yacht *Utowana*. Part I, Catalogue of the Species. *Field Col. Mus.* Botanical Series, Vol. ii, No. 1, 110 pp. — MILLER, G. S., Jr. Seven New Rats collected by Dr. W. L. Abbott in Siam. *Proc. Biol. Soc. Wash.* Vol. xiii, pp. 137–150. — OBERHOLSER, H. C. Notes on Some Birds from Santa Barbara Islands, Cal. *Proc. U.S. Nat. Mus.* Vol. xxii, pp. 229–234. — OBERHOLSER, H. C. Catalogue of a Collection of Birds from Madagascar. *Proc. U.S. Nat. Mus.* Vol. xxii, pp. 235–248. — OBERHOLSER, H. C. Notes on Birds collected by Dr. W. L. Abbott in Central Asia. *Proc. U.S. Nat. Mus.* Vol. xxii, pp. 205–228. — VAUGHAN, T. W. A New Fossil Species of Caryophyllia from California, and a New Genus and Species of Turbinolid Coral from Japan. *Proc. U.S. Nat. Mus.* Vol. xxii, pp. 199–203.

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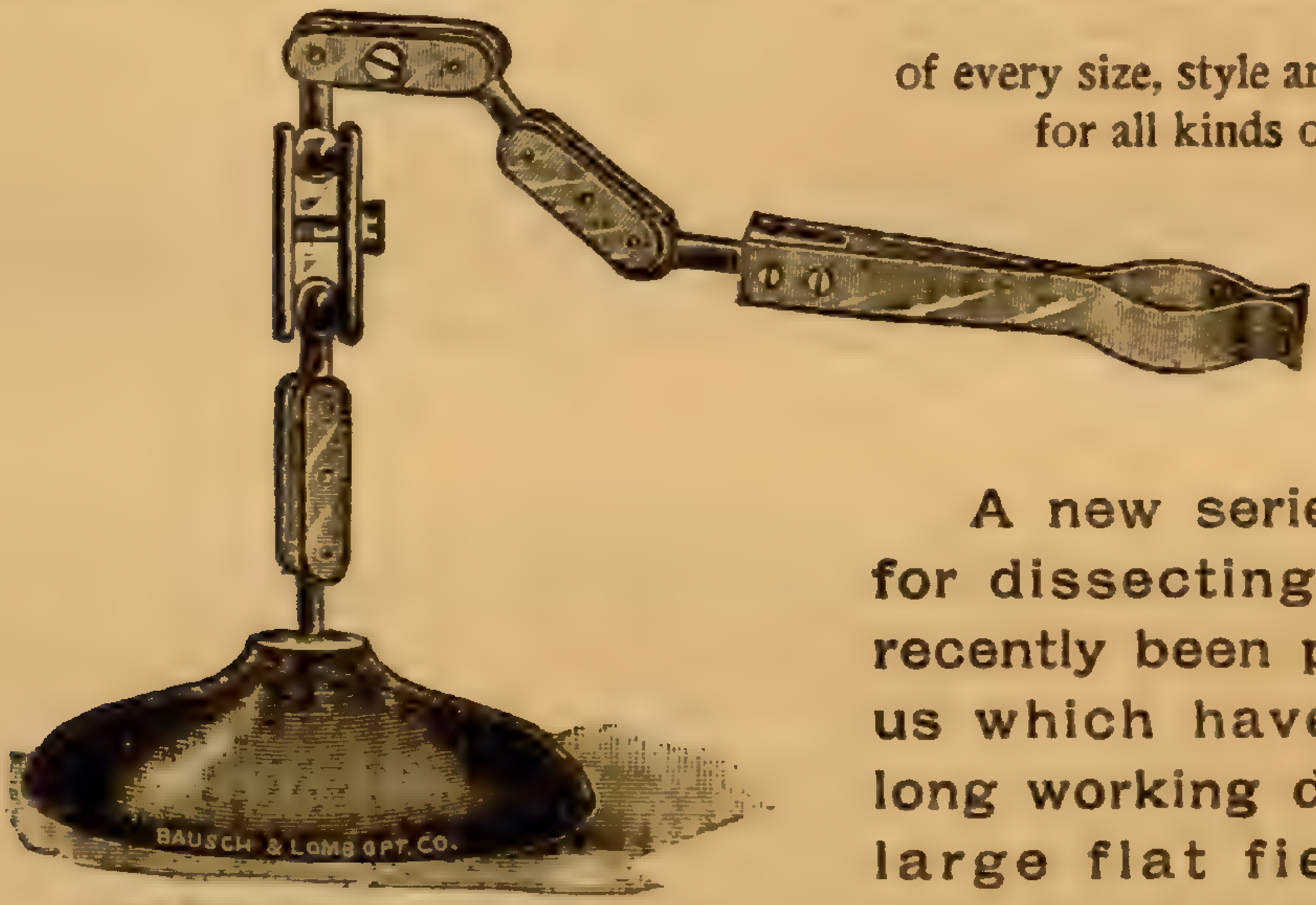

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IN THEIR WIDEST SENSE

CONTENTS

			PAGE
I.	**Notes on a Species of Pelomyxa**	Professor H. V. WILSON	535
II.	**A Remarkable Axolotl from North Dakota**	Professor H. L. OSBORN	551
III.	**The Female of Eciton Sumichrasti Norton, with Some Notes on the Habits of Texan Ecitons**	Professor W. M. WHEELER	563
IV.	**On the Linnæan Genera Myrmecophaga and Didelphis**	J. A. G. REHN	575
V.	**Karpinsky's Genus Helicoprion. A Review**	Dr. C. R. EASTMAN	579
VI.	**Synopses of North-American Invertebrates. XI. The Catometopous or Grapsoid Crabs of North America**	MARY J. RATHBUN	583
VII.	**Reviews of Recent Literature:** *Anthropology*, Man and his Ancestor, Notes — *Zoölogy*, A Zoögeographic Scheme for the Mid-Pacific, The Distribution of the Opilionidæ, The Management and Diseases of the Dog, Studies on Hirudinea, The Resources of the Sea, "Les Oiseaux," Heliotropism of Cypridopsis, Notes — *Botany*, An Experimental Botany, Prantl's Lehrbuch, "Lessons in Botany," Notes—*Paleobotany*, Cretaceous Plants, Fossil Cycads, The Yale Collection of Cycads, Fossils of the Norwegian North Polar Expedition, Rothamsted Experiments, Plants in Calcareous Tufa, Fossil Flora of the Cascade Range, Flora of the Coal Layers of La Ternera — *Paleontology*, Notes on Fossil Fishes		593, 594, 605, 608, 612
VIII.	**News**		613
IX.	**Publications Received**		615

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NOTES ON A SPECIES OF PELOMYXA.

H. V. WILSON.

IN rearing amœbas for class use, as every one knows, many interesting protozoa make their appearance. The Pelomyxa described in this communication developed in great numbers, something over a year ago, in a "culture" which had been prepared for this purpose. The method of preparation was one that I have employed for several years, and is as follows. Into an ordinary wooden tub (2 ft. by 1 ft.) sand is poured to a depth of four inches. The tub is then put under the tap of a table aquarium, and flushed until the water is comparatively clear. A good handful of Nitella, two or three opened mussels, and a crayfish, cut into a couple of pieces, are thrown into the water and partially imbedded in the sand. The tub is left exposed to a north light from large windows, at a distance of some yards from the windows. As decomposition progresses, a very gentle stream of water is turned on for a short time every few days. After an interval varying from two or three weeks to two months, large amœbas (*A. proteus*) are found in abundance in the surface layer of the sand, and on the sides of the tub. Small amœbas frequently appear in numbers before

the large ones come on. The commonest small form to appear is *A. radiosa* — occasionally *A. limax* (or some similar form). I have tried these tub cultures only during the warmer months of the year (April 1 to November 1). With rare exceptions they are successful. Mussels alone have frequently given me good amœbas, but the Nitella and the crayfish increase the chance of having enough to start with. The sand may come from anywhere, roadside or creek. The water is well water pumped into a reservoir tank. I am inclined to believe that a trace of mud, got along with the mussels or Nitella, is an advantage. But anything more than a trace is, here, sure to result in the development of Tubifex, which quickly spreads over the bottom, strewing it with fæces, while the amœbas, even if they get a start, gradually become scarcer, soon disappearing.

In the succession of organisms developing in such a culture, the bacteria are followed by the flagellate, and then by the ciliate Infusoria, both especially abundant in the surface film, where they feed upon the zoöglœa. A loose brown growth accumulates on the bottom, but more thickly on the wall of the tub. This consists of many things: fungus, hyphæ, bacteria, unicellular algæ, quantities of Infusoria, often Heliozoa (Actinophrys), and rotifers. The stuff gradually falls from the wall and accumulates on the bottom, round the edge. In this "growth" the small amœbas referred to above are often found, and in it *Stentor cæruleus* frequently develops in the greatest abundance. It is usually after this growth has begun to accumulate on the bottom, round the edge, that the large amœbas make their appearance. They are more abundant over the general surface of the sand than in the thick masses of brown stuff. By this time the Infusoria are no longer present in excessive numbers. The Entomostraca soon develop, and the amœbas gradually disappear. I think Cyclops is particularly destructive — it is constantly "rooting" in the sand. Frequently, before the arrival of the Crustacea, small planarians appear in numbers — *Microstomum lineare* has swarmed several times.

In a culture of this kind (mussels and Nitella both taken from a creek, the bottom of which in the particular locality is made up of soft mud, with abundant Tubifex), that had been

going during August, there appeared in the early part of September numbers of a large rhizopod belonging to Greef's genus Pelomyxa. After discovering the presence of the form, I examined the tub systematically and found that the Pelomyxas were about evenly distributed over the wall, and in the stuff round the edge, but were not present over the bottom, where Tubifex had already made its appearance. They were abundant. On the average, each pipetteful of stuff (about 2 cc.) contained a specimen, which could be detected at once with the naked eye in a watch glass. In the same brown growth *Stentor cœruleus* was present in great numbers, and the Pelomyxas were feeding chiefly on these. In the Pelomyxas recognizable pieces of Stentor were commonly present, and sometimes a whole Stentor still rotating. Unlike the Pelomyxas previously described, this form contained no mud nor sand.

The Pelomyxas continued to be abundant in the tub (preserving the same distribution) for nearly two months. Towards the end of this time they began to disappear, the Stentors going first. With the gradual disappearance of these forms, Crustacea, particularly Cyclops, developed. The probable share that Cyclops had in the destruction of the Pelomyxas was indicated clearly in the following case. On September 8, ten Pelomyxas were transferred to a small glass aquarium jar, together with some of the brown "growth" and a little Spirogyra. They were supplied, during the first few days, three times with Stentors in considerable number. Within five days the Pelomyxas increased in number to fifty odd. After a week or two, Cyclops began to appear, and the Pelomyxas diminished in number and soon disappeared. I never actually saw Cyclops seize a Pelomyxa, but the former was constantly darting into, or "rooting" in, the stuff in which the rhizopods lay. And the only animals observed in the jar, besides Cyclops and Pelomyxa, were small Infusoria.

In the following case the Pelomyxas obviously disappeared because of gradual starvation. In this case a number of the rhizopods were transferred, in September, to glass preparation dishes, of a size (30 mm. × 70 mm. in diameter) that would permit examination under a low objective. In these dishes was kept

clear water without any of the brown stuff or sediment, and the Pelomyxas were changed to fresh water occasionally. No Cyclops or other Crustacea developed in these dishes. For a time *Stentor cœruleus* was supplied, and later a small brown Stentor, Paramœcium, and other Infusoria. The Pelomyxas remained active and kept their size during this period, though they did not materially alter in number. After a few days they were no longer fed, though the dishes were kept supplied with fresh water. They gradually decreased in number, diminished very noticeably in size, and were very sluggish in their movements. The last of these individuals were made use of in early November. These starved individuals were about one-third the size of those originally put in the dish. It is possible of course that some division went on during this period of starvation, and that the shrinkage in size was not due merely to the loss of tissue.

To this form I have given the name of *P. carolinensis.* Its points of difference from the related species of Pelomyxa will be discussed later.

Description of Pelomyxa carolinensis.

Habitus. — The body, when viewed by reflected light, is white and conspicuous. When left for some time undisturbed (in small aquarium dishes suitable for microscopic observations), the body assumes a great variety of shapes, many of them indicating a high degree of consistency in the superficial layer of protoplasm. Owing to the large size of the species, these shapes may, with some success, be made out even with the unaided eye, though better with the help of a simple lens and low objective.

The body is very apt to assume an elongated, more or less rod-like shape, as in Fig. 1; sometimes enlarged at one end (clavate), as in Fig. 2. The elongated body may lie flat on the supporting surface, as in Figs. 1 and 2. More frequently the body is thrown into one or more curves, the animal resting on the bottom by its two ends, as in Figs. 3 and 4. Occasionally a Pelomyxa was observed in the remarkable attitude shown in

Fig. 5, a portion of the body resting on the bottom, while the rest of the animal, divided at the end into pseudopodia, projected freely upwards in the water. In this condition, Pelomyxa appears for the time being as an attached rhizopod with tentacle-like pseudopods, the nearest analogue to which is the interesting minute form *Stylamœba sessilis*, found by Frenzel[1] at Cordoba in Argentina.

If the animal in the undisturbed condition is not more or less rod-like, the body is frequently divided up into very long, slender pseudopodia, as in Figs. 6 and 7. In this condition the animal rests on the tips of certain pseudopodia, the rest of

Fig. 1.

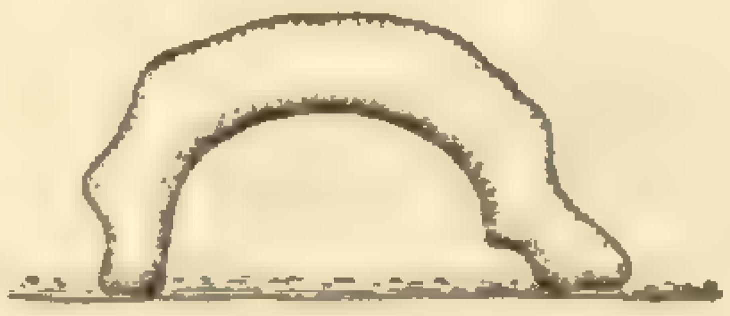

Fig. 3.

Fig. 5.

Fig. 2.

Fig. 4.

Fig. 1. — *P. car.* as an opaque object. Simple, elongated condition. Zeiss $a_2 \times 4$. Reduced to ½.
Fig. 2. — *P. car.* as an opaque object. Clavate condition. Zeiss $a_2 \times 4$. Reduced to ½.
Fig. 3. — *P. car.* as an opaque object. Body an arc resting on the two ends. Zeiss $a_2 \times 4$. Reduced to ½.
Fig. 4. — *P. car.* as an opaque object. Body somewhat spirally curved, resting on its ends. Zeiss $a_2 \times 4$. Reduced to ½.
Fig. 5. — *P. car.* as an opaque object. Body in part resting on bottom, in part protruding up into water, with tentacle-like pseudopods. Zeiss $a_2 \times 4$. Reduced to ½.

the body not touching the surface. The other pseudopodia project freely in the water in various directions, and the whole body is thrown into boldly arching curves, which usually lie in several planes. When the animal is in this condition, with its irregular body extending in so many directions, it obviously dominates (*i.e.*, can gather food from) a much larger cubic space than when in the simple rod-like condition. Now in that aquarium jar in which the Pelomyxas were best fed, and in which they increased so considerably in number (ten to fifty in five days), some form of the rod-like shape was nearly universal. Here the food (Stentors and other Infusoria) was most abun-

[1] Untersuchungen über die mikroskopische Fauna Argentiniens. Protozoa. *Bibliotheca Zoologica*, Heft 12, 1892–97.

dant in the brown "growth," with which the bottom was strewn. With the food thus distributed, the worm-like shape was doubtless well adapted to the situation. On the other hand, in those dishes containing no sediment or brown "growth," but simply clear water, and in which the Pelomyxas did not increase in number, the irregular, branched condition (Figs. 6 and 7) was extremely common. In these dishes it is evident that food was scarce from the start, and the peculiar shape of the Pelomyxas is probably to be regarded as an adaptation to circumstances. We may think

1 mm.

FIG. 6.

FIG. 7.

FIG. 6. — *P. car.* as an opaque object. Body thrown into bold curves and complexly branched, resting on bottom (indicated by lines) at four points. Remaining pseudopodia project freely into water. One millimetre drawn to same scale. Zeiss $A \times 2$. Reduced to ½.

FIG. 7. — *P. car.* as an opaque object. Body thrown into two curves, lying in planes nearly at right angles with each other. Body rests on bottom (indicated by lines) at four points, one pseudopodium projecting freely upwards. Zeiss $A \times 2$. Reduced to ½.

of the animals as thrusting their substance out in all directions of space, searching for food.

When brought on a slide in a drop of water, these animals assume the general shape of *Amœba proteus*. The body expands in a horizontal plane, and is, as a whole, applied to the surface over which it is creeping (Fig. 8). This is the case whether the drop be uncovered or covered — cover was always supported with wax feet, so as to permit free movement. This flattened shape is not directly caused by confinement between two surfaces (surface film and slide, or cover and slide), because it is also usually assumed when the Pelomyxa is first placed in

a watch glass with plenty of water. It would appear to be the shape into which the amœboid body, more or less contracted after the reception of a shock, normally expands, before assuming any more characteristic habitus. If the Pelomyxa, owing to the shock of having been transferred to the watch glass, has contracted into a very compact shape, it may (rare condition) throw out short radial pseudopodia all over its body, excepting the lower surface (applied to the glass), Fig. 9. This condition is transitory, soon passing into the stage shown in Fig. 8.

FIG. 8. — *P. car.* moving freely, on slide, under supported cover. Arrows indicate direction of endosarcal currents. Longitudinal, and papillose wrinkling at the ends of pseudopodia, out of which current is flowing. Only the most conspicuous vacuoles, nuclei, and albuminous globules represented. Zeiss *A* × 2. Reduced to ⅔.

Size. — In the relatively contracted shapes (Figs. 8 and 9) *P. carolinensis* measures about 1 mm. in diameter. The largest form actually measured, in which the body was of the slender irregular character shown in Figs. 6 and 7, measured in a straight line from pseudopodium tip to pseudopodium tip 2.8 mm. Some two hundred specimens of this species were examined by myself and the class demonstrator during September; and for the elongated shapes, the length may be said to vary from 1 to nearly 3 mm., the common length being 1.5 mm. to 2 mm. These measurements may

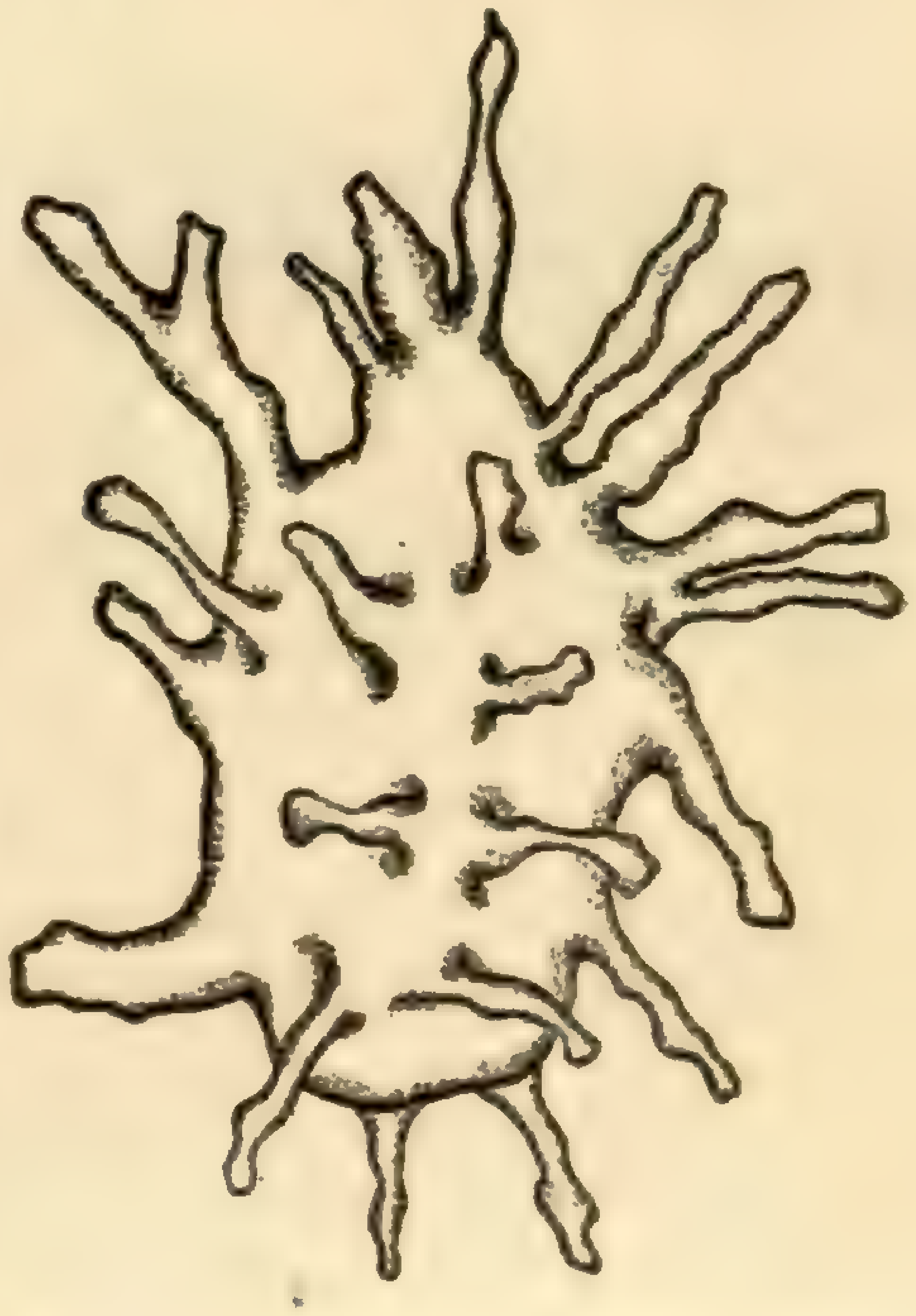

FIG. 9. — *P. car.* as an opaque object. Shortly after having been transferred to watch glass. Body covered with short radial pseudopods. Zeiss a_2 × 4. Reduced to ⅔.

be taken as characteristic of the adult condition, since the Pelomyxas were always picked out with the unaided eye, no effort being made to discover young forms with the microscope.

Structure of the Body. — There is a perfectly clear peripheral (ectosarcal) region, which in the living state is very narrow, being conspicuous only at the ends of expanding pseudopodia (Fig. 8). The granular, more opaque and fluid endosarc contains numerous nuclei, vacuoles, and other bodies. Though the endosarc is naturally lighter near the edge than further in, this difference in transparency is due to a difference in thickness and not to a difference in composition. The nuclei are very abundant, and scattered without order through the endosarc. They are elliptical in shape, and measure $18\,\mu \times 16\,\mu$ (typical case). The vacuoles in the endosarc vary greatly in size. Large ones, distinct with an a_2 (Zeiss) objective, and often measuring $40\,\mu$ in diameter, are scattered about in some abundance. When the body is compressed, or when sections are examined, the endosarc is seen to be honeycombed with vacuoles of all sizes; the very small ones, a few microns in diameter, being especially abundant. So abundant are the vacuoles in parts of the endosarc that the optical effect (in section or thinly expanded pseudopodium) is that of a spongy reticulum.

There is no contractile vacuole in this form. If a vacuole disappears, it does so simply because of the shifting of the protoplasm. The endosarc contains in the greatest abundance minute crystals, which contribute very materially to its dark appearance with transmitted light. These bodies are of an elongated fusiform shape, about $2\,\mu$ in length. When seen end on, they look like dots. They are readily soluble in alcohol and in dilute acetic (used in acetic carmine and methylgreen solution), but are neither stained nor dissolved by one per cent osmic. Their diminution in size and gradual disappearance, when treated with the above solvents, may be watched under the microscope. It requires but a few minutes for them to vanish completely, leaving the other inclusions much more distinct than they formerly were.

Scattered abundantly through the endosarc are spherical bodies, having in the living animal a bright appearance with a dark contour, and looking much like oil drops. They very commonly have a diameter of about 8 microns, though smaller ones of all sizes are present. These bodies evidently correspond to the "Glanzkörper" originally described by Greef[1] in *P. palustris*, although in the latter form they may reach a much larger size than I have observed in *P. carolinensis*. These "refringent bodies," as Gould[2] calls them, are insoluble in alcohol. They are stained by osmic acid and by iodine (alcoholic solution), in nowise differently from the granules of the endosarc (*i.e.*, are browned). They cannot, therefore, be of a fatty or starchy nature. The contents of the bodies is fluid, as may be demonstrated by allowing the Pelomyxas to be gradually compressed through the slow evaporation of water from under the cover-glass. At a time when the arrangement of the coarser and finer granules of the protoplasm is not interfered with, the globules burst and run together, suggesting fat droplets very strongly, but even in this condition osmic acid does not blacken them. On the other hand, the globules are stained a deep blue with hæmatoxylin. In sections (fixed in Zacharias, stained with Delafield's hæmatoxylin) it may be seen that the endosarc is thickly studded with coarse granules, which stain blue with hæmatoxylin. The smallest refringent bodies, recognizable as such, differ but little in appearance from these coarse granules. They are slightly larger, of a more rounded shape, and take a deeper stain. From these minute globules, all gradations in size may be found up to the large ones, 8 microns in diameter. With the increase in size the depth of coloration increases — an effect due doubtless to the greater diameter. The bodies, when stained with hæmatoxylin, present a perfectly homogeneous appearance. From the evidence at hand, it would seem to me that the bodies are globules of an albuminous nature, consisting of a pellicle, enclosing a more fluid substance. Greef (*loc. cit.*) inclined to the

[1] *Arch. f. mikr. Anat.*, Bd. x, 1874.

[2] Notes on the Minute Structure of Pelomyxa palustris. *Quart. Journ. Micr. Sci.*, vol. xxxvi, 1894.

belief that the "Glanzkörper" were of intranuclear origin, and were concerned in reproduction. Gould (*loc. cit.*), working on *P. palustris*, failed to see evidence for the truth of these ideas, and in the form which I have studied there was no such evidence. Gould found the "Glanzkörper" to have a homogeneous appearance when stained with ordinary stains (the exception does not seem to have any special significance); and she reached the conclusion that they were "almost certainly either solid structures or filled with coagulable fluid." With the latter alternative I agree.

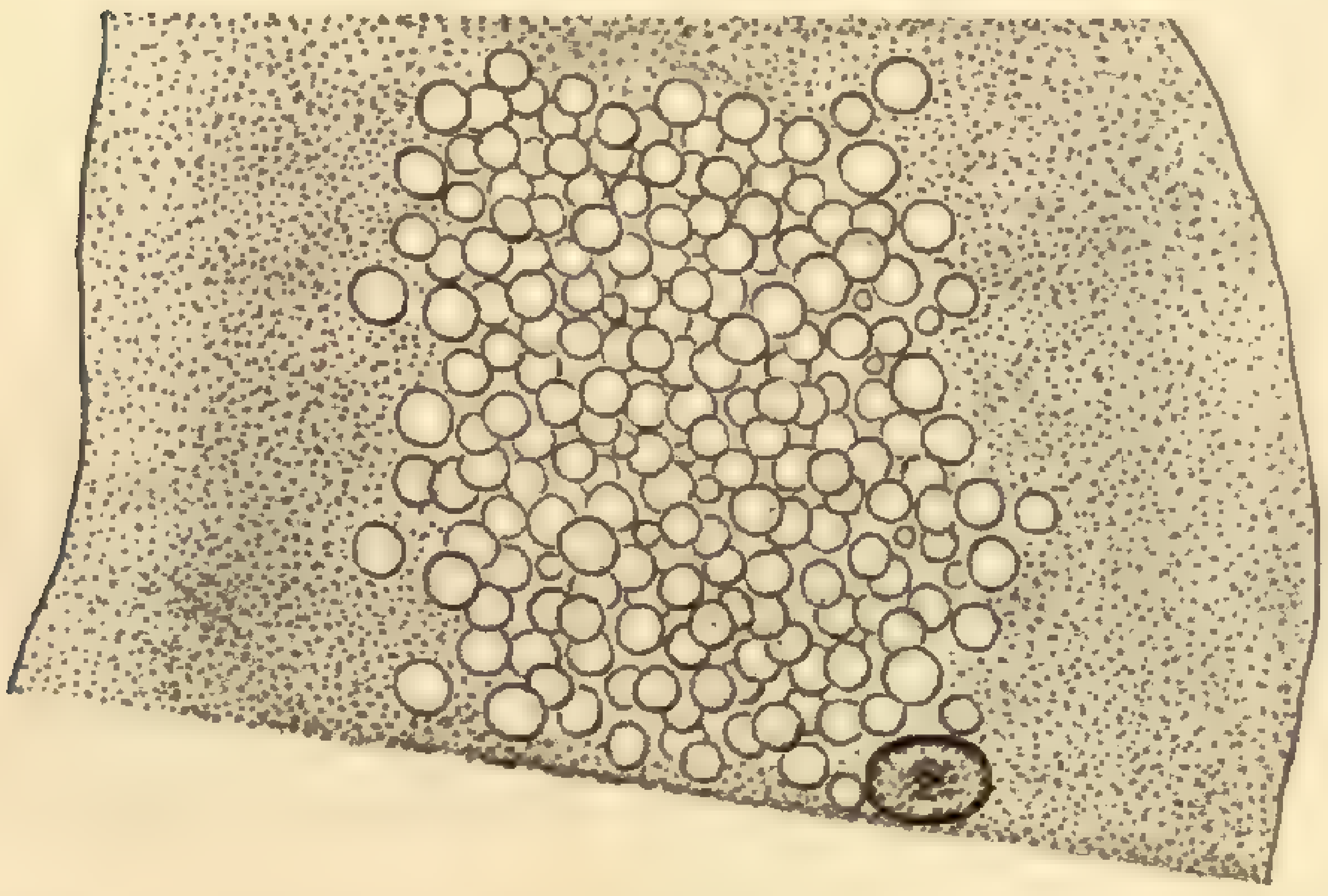

FIG. 10.— Portion of a starved Pelomyxa. Crystals dissolved out with alcohol. Drawn in water. Zeiss $D \times 4$. Reduced to ⅔.

The condition of the albuminous globules in starved individuals deserves a word. In healthy, active specimens the globules are scattered all through the endosarc. In certain individuals kept without food in pure water for several weeks, the globules were much more numerous than in normal specimens, and were aggregated together in several regions of the body. In each such region (Fig. 10) the globules were thickly crowded, while elsewhere they were nearly absent. These starved Pelomyxas were about one-third the common size of healthy specimens, and were exceedingly sluggish in movement.

In specimens of Pelomyxa kept without food for some time the body contains no inclusions except such (granules, crystals, albuminous globules) as seem to be normal and constant constituents. Owing to its large size and freedom from foreign inclusions, *P. carolinensis* presents certain marked advantages for the study of the fundamental structure of protoplasm. As a living object it is perhaps no better than smaller rhizopods, though under a cover-glass the pseudopodia may flatten out into very thin sheets. On the other hand, it is easy to handle for sections, and in sections the vacuolar walls in particular are instructive. One of the large vacuoles may be cut into several sections, and will thus afford both true sectional and surface

views of its wall. For comparison with the living animal I have found it useful to employ surface preparations of specimens mounted in glycerine, after killing with acetic carmine or acetic methyl green; or surface preparations of specimens killed in alcohol and mounted in water. Acetic carmine (45 per cent acetic) kills the animal as quickly as an osmic fixative, the outline of the living state being faithfully retained. Alcohol and acetic methyl green kill more slowly, the animal undergoing some change of shape, which involves especially the peripheral region. On addition of these fluids the coarsely granular endosarc either contracts, or the surface film of the Pelomyxa is raised up by absorption of fluid. That the latter is the case, is the impression made on one when the animal is kept under observation during the action of the fixative — the surface seems to rise up often in bleb-like swellings. The result, at any rate, is that the clear ectosarcal region, very narrow in life, is greatly increased in width, and thus a considerable area, exhibiting the fine reticular (alveolar) structure characteristic of this region, may be had for study.

The general endosarc lying between the vacuoles shows the greatest abundance of coarse granules so closely set that they must obscure whatever finer structures are here present. These granules very commonly have a diameter of one micron, though smaller ones of varying size are abundant.

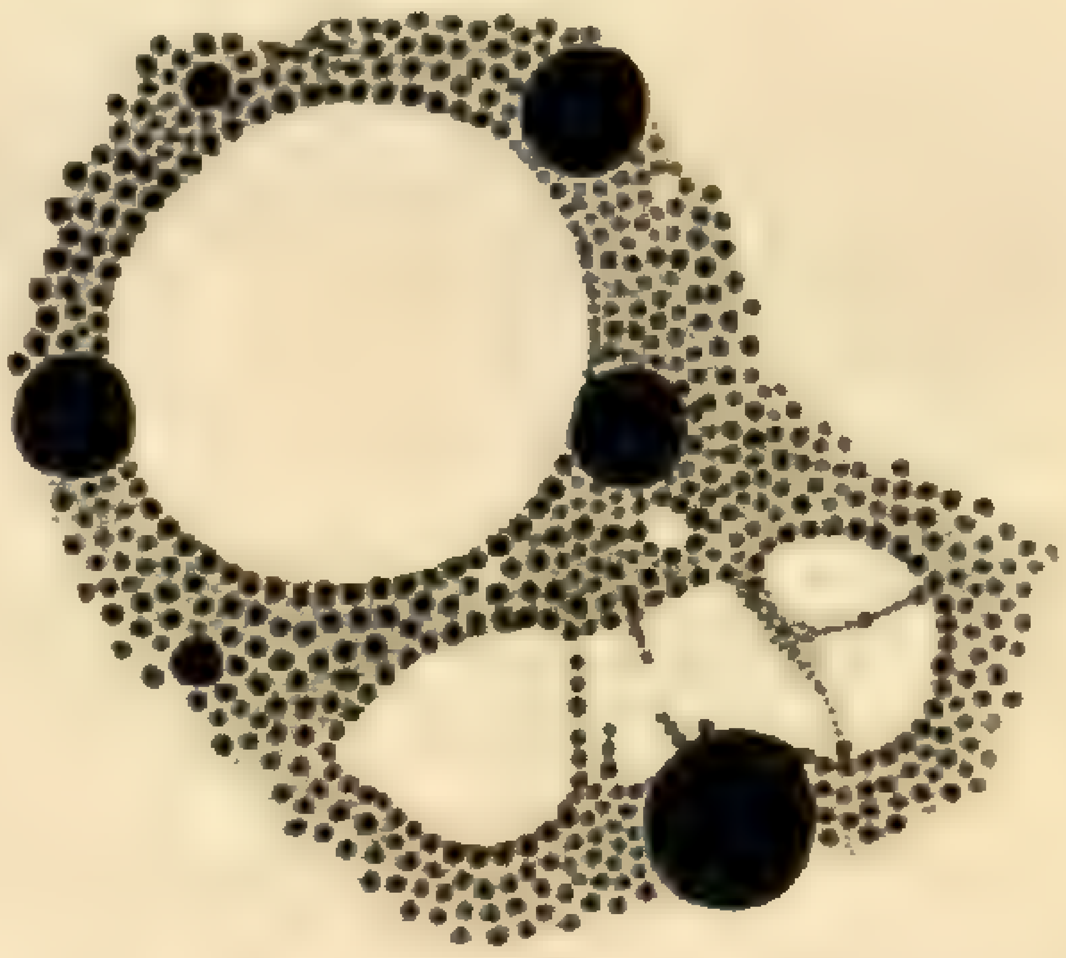

Fig. 11. — Part of section showing vacuoles, deeply stained endosarcal granules, and several deeply stained albuminous globules. Zeiss $\frac{1}{12}$ × 4. Reduced to $\frac{2}{3}$.

In sectional view (Fig. 11) the walls of many of the larger vacuoles seem made up of similar coarse granules, arranged regularly so as to form a smooth bounding surface for the cavity. These bounding granules are generally about 1 μ in diameter, but in places they may be much smaller, ranging down to the size of microsomes. Long vacuoles are occasionally found somewhat constricted, so as to be incompletely divided up into chambers (crenellated vacuoles of Gould, *loc. cit.*), as in Fig. 11. Intravacuolar strands may be seen in these vacuoles. In

some cases the strands are undoubtedly the free edges of folds. Some of the strands consist of a single row of comparatively large granules (intermediate in size between the microsomes and the coarse endosarcal granules), easily counted, and which are connected by the finest lines (fibres), in which no structure can be made out with $\frac{1}{12}$ Zeiss. Other intravacuolar strands are of considerable thickness, appearing as a mass of finest granules (microsomes) closely set, in which a coarse granule is found here and there. Still other strands appear as exceedingly delicate lines, made up of one row of microsomes.

In surface views of vacuolar walls, studied in sections, the same appearance is not always had. In many cases the wall seems made up of microsomes, arranged so as to give in places the appearance of a reticulum, the mesh of which is in the neighborhood of a micron. Interspersed among the microsomes much larger granules are found here and there, connected by fine strands, which often consist of a row of microsomes, though in other cases the connecting strand appears as a homogeneous line. In other vacuoles (always of considerable size) the wall when seen in surface view exhibits coarse granules, set regularly and almost as closely as in the intervacuolar endosarc, between which run fine strands. If microsomes are present in such a wall, their presence is obscured by the coarser reticulum.

The ectosarc in even a thinly expanded pseudopodium looks nearly homogeneous ($\frac{1}{12}$ Zeiss) in the living animal. In acetic carmine preparations mounted in glycerine, and in alcohol or acetic methyl-green preparations mounted in water, the ectosarc may be seen to be occupied by a delicate reticulum, the mesh of which is close to 1 μ. I was not able to decide with certainty (working, however, only with Zeiss $\frac{1}{12}$) whether the microsomes are always situated at the points of intersection of the reticular lines (lamellæ of Bütschli), or whether each (apparently) linear side of a mesh included a short row of microsomes. Dispersed in this delicate reticulum, which seems identical with that seen in many vacuolar walls, are to be found here and there a few coarse granules.

The fine ectosarcal reticulum, in a fixed specimen examined

in water under an unsupported cover, may be seen with a Zeiss $\frac{1}{12}$ to enter into the composition of the surface film. This now appears as a row of microsomes connected by strands. On the other hand, when the Pelomyxa is examined under a supported cover-glass with a dry lens, the superficial membrane has an appreciable thickness and is plainly doubly contoured. Blochmann[1] mentions that in his Pelomyxas the "Hautschicht" seems to have a double contour. The doubly contoured appearance of the surface membrane is, I believe, due to the arrangement of the superficial meshes (alveoli of Bütschli), which, as Bütschli[2] has shown in so many cases, are arranged in a layer with the partition walls vertical to the surface. That is, the membrane appears doubly contoured, because we see the outer and inner walls of the meshes of the superficial layer, and fail to distinguish the partition walls between the several meshes. Under slight pressure the reticular (alveolar) structure comes into view.

In these few notes on the finer structure of the cytoplasm I have used the terms "microsomes" and "reticulum" as indicating the optical appearances obtained, and not with the intention of expressing a belief that the structures as such have an actual existence.

In *P. palustris* the regularly arranged coarse granules, described above as present in vacuolar walls, are not figured by Gould (*loc. cit.*). In *P. carolinensis* they may easily be seen in the living specimen. The regularity of their arrangement at first sight suggests that they are not, to use some apt expressions of Mrs. Andrews,[3] mere "passive chemical inclusions," but are "physiological areas or substance organs," *i.e.*, permanently differentiated portions of the living substance. On the other hand, they are not always present throughout the extent of the vacuolar wall, and in many vacuoles are absent or nearly so. The presumption is thus a fair one that the bodies are mesostates, and owe their regular arrangement (in places) to the underlying fine reticulum.

[1] Kleinere Mittheilungen über Protozoen, *Biol. Centralbl.*, Bd. xiv.

[2] *Investigations on Microscopic Foams and on Protoplasm.*

[3] *The Living Substance*, p. 16. Boston, 1897.

The number, shape, and size of the nuclei have already been alluded to. The chromatin granules are extremely numerous, especially abundant just within the nuclear membrane. They also form a densely crowded large mass in the center of the nucleus. Between the peripheral layer and central mass, the nucleoplasm comes into view more conspicuously than elsewhere. The granules are connected freely by intervening delicate strands, which themselves often show a row of finest granules. The granules, as a whole, are too crowded to permit decision as to whether a continuous reticulum exists. The chromatin granules vary in size from that of the cytoplasmic microsome up to much larger ones, 1 μ in diameter, the size of the common coarse granules in the wall of vacuoles.

Motion. — I regret not to have studied the currents of the body, when the animal is in those shapes in which it is only applied to the surface at isolated points (Figs. 3–7). At such times a locomotory motion, if it existed, escaped my notice. The animal was at rest for sufficiently long periods of time to permit careful study and drawing.

When the body is linear and applied throughout its extent to the surface, as in Figs. 1 and 2, the motion is, in general, similar to that of *P. villosa*,[1] or of the form commonly known as *Amœba limax.* As has already been said, *P. carolinensis*, when placed on the slide, assumes the habitus of *Amœba proteus* (Fig. 8). In this condition the movements are active, the pseudopodia being protruded in, or nearly in, a horizontal plane, but in any direction. The difference in appearance between pseudopodia into which the current is going, and those out of which it is flowing, is in this condition very noticeable. The contour of the former is smooth, the pseudopodia having an appearance of plumpness and distention. In the latter case, on the contrary, the surface is thrown into "mulberry-like" folds at the ends of the pseudopods. Moreover, it can frequently be seen in such a pseudopodium that the upper surface is thrown into longitudinal wrinkles. These are shown in two of the pseudopods in Fig. 8. The appearance of these pseudopodia is in perfect harmony with Bütschli's description (*loc. cit.*,

[1] Leidy. *Fresh-Water Rhizopods of North America*, p. 73.

p. 313) of the backward flow of protoplasm from a pseudopodium: "The viscid external layer cannot flow together rapidly enough to keep pace with this diminution, in consequence of which it is thrown into folds, etc." Returning to the expanding pseudopodium, I may say that Wallich's remarks on *Amœba villosa*, quoted by Leidy (*loc. cit.*, p. 75) as applying to *P. villosa*, aptly describe the appearances to be had in *P. carolinensis*. After the local thickening of ectosarc, which precedes the formation of a pseudopodium, there is a *sudden* inrush of granules. The very suddenness of this inrush inevitably suggests that something in front has burst or given way, rather than that something behind has *begun* to contract, and, as far as it goes, is an argument for Bütschli's theory (*loc. cit.*, p. 311), that the formation of a pseudopodium is primarily due to the bursting of superficial alveoli, whereby (through the action of the enchylema on the free surface of the protoplasm) the surface tension in that locality is diminished.

Systematic. — In the assumption of complexly branched shapes (Figs. 6 and 7) *P. carolinensis* differs from the described conditions of the type species, *P. palustris* Greef, and of *P. villosa* Leidy, which are habitually more or less slug-like when in motion, and of massive shape when at rest. The peculiar posterior "villi" characteristic of the latter form are absent in *P. carolinensis*, which, moreover, differs from both forms in the fact that it does not gorge itself with mud, and that it contains no "Stäbchen" or symbiotic bacteria, as they are believed to be by Gould (*loc. cit.*) and some other observers. The Glanzkörper (albuminous globules) are present in Greef's species, and Leidy describes them in *P. villosa*. Blochmann (*loc. cit.*) and Frenzel (*loc. cit.*), however, mention their absence in the forms which they identified as belonging to *P. villosa*. The minute crystals which I find so abundantly in *P. carolinensis* are apparently not present in *P. palustris*. Neither Greef nor Gould mentions them, nor were they found by Leidy in *P. villosa*. Possibly the granules which Blochmann finds in such quantity in some of his Pelomyxas correspond to my "crystals." The Pelomyxas in which Blochmann finds the granules abundant have large and conspicuous Glanzkörper,

round which the Stäbchen never form a mantle. Blochmann groups these forms under *P. palustris*. Other forms Blochmann unites under the provisional species, *P. greefi*, characterized by the almost complete absence of the granules, and by the small number of Glanzkörper, which are always surrounded by a thick coating of Stäbchen. The peculiar habitus assumed at times, absence of sand in the body, absence of Stäbchen, presence of the crystals, are the distinguishing characteristics of my species against the related forms, *P. palustris*, *P. villosa*, *P. greefi*.

The habitus in rhizopods, however, is undoubtedly a most inconstant feature, readily affected by the individual environment, as may be learned from *P. carolinensis* itself. The interesting observations of Verworn (*Allgemeine Physiologie*, p. 190) on the change of shape in amœbas, through the *A. proteus*, *A. limax*, and *A. radiosa* condition, likewise indicate this. And it seems probable, from the diverse forms of Pelomyxa, that Blochmann (*loc. cit.*) has found that the cytoplasmic inclusions, even the characteristic Glanzkörper, are all inconstant, and are to be looked on as the outcome of the individual environment. A greater familiarity with the four above-mentioned forms may thus show that they all belong to a single species.

University of North Carolina,
December 18, 1899.

A REMARKABLE AXOLOTL FROM NORTH DAKOTA.

HENRY LESLIE OSBORN.

THE name "axolotl" is primarily the popular designation among the Mexicans for an animal found abundantly in their lakes. The name "siredon" has also been applied to this and allied animals, at first as a generic name, till that was shown to be superfluous by the demonstration of the amblystomid nature of the axolotl, or siredon, larva. The Mexican axolotl is said not to metamorphose from an aquatic to a terrestrial form after the manner of Amblystoma, but to be a permanently aquatic animal, thus imitating Necturus physiologically, with which, however, it has no morphological relationship, as indicated by the fact that Necturus has no free gula folds or opercula, only two gill slits, no dorsal fin, a much shorter tail, and only four toes in the hind limb. It had early been strongly surmised that the axolotls were amblystomas, but Dumeril of Paris in 1865 was the first to observe the metamorphosis of axolotls into true adult amblystomas. Specimens in the Jardin des Plantes laid eggs which in developing did not stop when they reached the form of their axolotl parents, but continued to develop, losing the gills and many other larval features and becoming true terrestrial salamanders. Dumeril's observations were corroborated by Marsh in 1868, by Tegetmeyer in London in 1870, and by Madame Chauvin in 1874. The latter managed to arrange an experiment in which young tadpole larvæ were gradually transferred from an aquatic to a terrestrial environment, resulting in the correlated metamorphosis to the terrestrial form.

While Dumeril, Tegetmeyer, Marsh, and Chauvin have shown that an amphibian with the characters of the Mexican axolotl does metamorphose into a salamander under some conditions, it has not been satisfactorily shown as yet that the

Mexican form does so, for it is contended by Cope ('89) that all of these have been working, not with the Mexican form, or "true axolotl," but with larvæ of *Amblystoma tigrinum*. The latter have been found in several localities in this country. In 1852 Professor S. F. Baird described the external features of a siredon, called by him *Siredon lichenoides*, from Santa Fé Creek, New Mexico, and later, in 1859, the same writer described another, which he called *S. gracilis*, from the Cascade Mountains, near the fortieth parallel of latitude. This writer did not observe the transformation of siredon (though he conjectured it); but in 1868 Professor O. C. Marsh of Yale College collected siredons in a lake in Wyoming, at a level of 7000 feet above the sea, and conveyed them to New Haven, where they transformed into *A. tigrinum*. Tegetmeyer ('70) figures an *S. mexicanus*, which, while in his possession, transformed into an *A. tigrinum*. It appears from his figure to be identical with Baird's *S. lichenoides*. In all these cases, however, it will be noticed that the siredons were not in their normal surroundings, and hence it is not decided whether their transformation takes place in nature or whether they reproduce while still in possession of the larval characteristics. There is a great difference between merely a greatly overgrown true larva, one not yet capable of reproduction, and the condition of the axolotl in which the reproductive organs are matured before the other organs in the other systems have reached the form that they have in adult amblystomas. It is not impossible that both conditions exist, a siredon in which the animal is a true larva not yet matured, and an axolotl in which the animal is at once a larva and a mature form.

In this sense Marsh's specimens would be siredons, and Dumeril's first generation axolotls, and the second siredons. After the matter of this article had been made nearly ready for the press I had my attention called by Dr. T. G. Lee of the Minnesota State University to a collection of about twenty-five specimens of an axolotl which seems to be very similar to Marsh's *S. mavortium*, and which were found by him in an alpine lake in Montana. Dr. Lee has most generously placed all of this material (which is splendidly preserved in formalin)

Fig. 1.

Fig. 2.

Fig. 1. — Dorsal view of Dakota axolotl — one-half natural size.

Fig. 2. — View of right side of Dakota axolotl, one-half natural size; the number of toes in the hind limb here is abnormal and should be five.

at my disposal, and a survey of its contents shows me that, while it is decidedly unlike the axolotl described in this paper, it is suitable for the study of a number of points in the anatomy of the axolotl, on which at present only the most scanty information is in print. I hope to make this material the subject of a second paper, which will follow this one at a later date. I desire in this connection also to express my obligation to Professor L. Stejneger of the U. S. National Museum, and to Professor H. H. Wilder of Smith College, Northampton, Mass., for their suggestions with reference to the bibliography of this subject.

The Dakota specimen shown in dorsal and side views in Figs. 1 and 2 differs from previously known forms, including the Montana ones of Dr. Lee, in a number of anatomical points, and besides it comes from a region that is very different in geographical conditions from all regions previously reported.

It is known by only a single specimen, which was sent to the writer for identification by Miss Prudence Tasker of Amenia, North Dakota. It was found on March 21, 1899, in Rush River, a tributary of the Red River of the North, a situation described by the sender as "called a river merely by courtesy, — a stream that rises in a marsh and ends in a marsh, — dries up every summer, except in little pools." The stream is mostly shallow, but at one place has been made deeper by a dam, and here the specimen was found. The stream contains limited numbers of the smaller kinds of fish. It was found by a workman who had cut a hole in the ice to water horses, and while baling snow out of the hole baled this specimen out with the snow. He was attracted to it by seeing it crawl. It was taken to the store of Mr. Mosberg in Amenia, where it was examined by many persons, none of whom were familiar with anything like it. It died after a few hours and was sent to me packed in snow, and some drawings and measurements were made while it was still fresh.

Since receiving this specimen another has been reported by Miss Tasker; it was found by Mr. G. Makee in June, 1898, at Kenmare, North Dakota, on the bank of Mouse River, in

shallow water. This specimen was seen by Miss Tasker and identified as the same as the one herein described. It measured eight inches in length. These specimens, coming as they do from lower levels and not from alpine localities, and from northern, in contrast with the warmer southern levels of most of the former discoveries, are interesting and hold out some prospects that a study of these creatures in their natural surroundings would throw light on the problem of the relationship of these peculiar larvæ to the amblystomas. The general appearance is shown in the accompanying drawings, which were made from the formalin specimen. The following dimensions were also taken from the specimen after preservation in formalin, but both were compared with the data from the fresh animal:

Chin to tip of tail	312 mm.
" " border of gular fold	35 mm.
" " armpit (posteriorly)	72 mm.
" " center of pelvic arch	159 mm.
" " posterior edge of cloaca	192 mm.
Snout to line joining hinder angle of gills	59 mm.
Greatest height of tail	32 mm.
" thickness of tail	18 mm.
" height of dorsal fin	08 mm.
" diameter of head	55 mm.
Width of mouth	30 mm.
Distance between anterior nares	14 mm.
" " posterior nares	18 mm.
" " centers of eyes	26 mm.
Width of head at eyes	39 mm.
Snout to line joining centers of eyes	13 mm.
Length of filament-bearing border of first gill	45 mm.
" " second gill	53 mm.
" " third gill	69 mm.
" " arm	24 mm.
" " forearm	17 mm.
" " hand	19 mm.
" " thigh	19 mm.
" " fore leg	19 mm.
" " foot	22 mm.

The animal displays a combination of larval and adult characteristics in its exterior form. The main lines are those of

Amblystoma, and many of the proportions are closely similar, and this similarity extends to the internal organs, which are even more like those of the ordinary form of Amblystoma than are the external parts. In point of size it greatly exceeds the average of Amblystoma and goes beyond the maximum reported length by 30 mm. The lengths of fifteen specimens, taken from a collection made at St. Paul, of *A. tigrinum* are as follows: 122, 128, 134, 140, 151, 160, 165, 165, 167, 170, 185, 187, 200, 204, 220 millimeters. The Dakota specimen is almost 100 mm. longer than the longest of these and much more considerably exceeds their average. Cope ('**89**) reports a specimen of 250 mm. from Wisconsin, and quotes De Kay for another of 280 mm. The Dakota specimen thus exceeds the recorded maximum length of Amblystoma by over one inch. A special detailed comparison of the dimensions of the separate organs will be made in connection with each of them, and we may pass at once to a survey of them in succession.

There is a considerable difference between the Dakota specimen and the adult amblystomas in the character of the skin, both as to coloration and as to the character of the surface. As to the former point in this axolotl the general color is dark livid blue, with a lighter area in the middle dorsal region, instead of the jet-black color found dorsally everywhere in *A. tigrinum*. On this ground are occasional large circular dark spots. This coloration is in marked contrast with adult *A. tigrinum*, where we find bright yellow spots of a great variety of irregular shapes, often elongate and confluent, and with either *S. mexicanum* or *S. lichenoides*. In the former "a pinkish gray ground is covered with numerous small, round, dusky spots rather closely placed" (Cope, '**65**, '**89**), and in the latter the ground color is blackish brown, with irregular patches of grayish yellow, "reminding one of the growth of lichens" (Baird and Girard, '**52**, p. 336), much as in the adult form of *A. tigrinum;* while in Baird's *S. gracilis* the body is marked with very small and numerous dark spots that give it a decidedly mottled appearance.

In addition to this difference in coloration the skin of the Dakota form differs from the texture of the adult and, as far

as I can tell from figures, from that of the other larval forms. It is not smooth, but is somewhat coarse and warty-roughened, generally on the back and sides; but this condition is replaced on either side of the dorsal fin by a narrow area in which the skin is entirely smooth. This difference in texture is noticeable. It is not shown in Baird's figures, but it is possibly indicated in Marsh's, so that it may exist in some stages, at any rate, of their forms.

The head in the Dakota form and in all the siredons is quite different from that of the adult *A. tigrinum.* Dorsally it is flattened as in *A. tigrinum*, but ventrally it is swollen and rounded so as to present in a side view a very different appearance; this difference is directly correlated with the presence of the branchial apparatus. The whole head, however, is relatively larger here (and in the Montana form) than in the adult *A. tigrinum.* The measurement of the length of head is made from the line connecting the posterior boundary of the gill; the location of this is still visible as a rudiment in the adult, and thus furnishes a very constant point from which to measure. For comparison with this I have taken the distance to the hinder boundary of the cloaca, which gives the length of the trunk, to compare with that of the head, as being more accurate than to take the total length. There is some variation in the sizes of all these regions, and by taking the head and comparing it with the trunk the influence of variation is less than it would be if the two regions of trunk and post-abdomen were both taken.

The length of the head in the Dakota specimen is 31 per cent of the length of head and trunk together. This is relatively larger than the head of *A. tigrinum* in the larger sizes of the species. Thus it is found in a series of twelve specimens that the length of head ranges from 31 per cent of head and trunk, in the shortest cases, to 25 per cent in the longest ones. If this ratio were followed out, the length of head for a specimen 312 mm. in length would be only 20 per cent of head and trunk, in contrast with 31 per cent as here. This point of size of head shows even more distinctly in Dr. Lee's Montana forms than in this one from Dakota, for there the range is

between 38 per cent and 30 per cent, in all cases about 5 per cent greater than for adults of *A. tigrinum* of the same total length. The distance between the centers of the eyes is less than in the adult Amblystoma, where the eyes, instead of being located considerably inside of the margin of the face, are lateral. The area of the face, in front of the line connecting the centers of the eyes, is also less than in the adult. In the latter the distance from the snout to this line is generally about one-third of the length of the head, while in the Dakota form it is one-fifth. The diameter of the mouth opening, too, is less than in the adult of *A. tigrinum*, in that the angle of the mouth coincides with the angle of the jaw; in other words, there are no developments of free skin, forming lips or cheeks, and the angle of the mouth is located directly under the eyes; but here, while the angle of the jaws is beneath the eyes, there are folds of skin forming lips and a sort of cheek cavity, so that the angle of the mouth lies anterior to the level of the eyes.

FIG. 3. — Ventral view of throat and jaw of right side of Dakota axolotl, with the gular fold (*g.f.*) turned forward so as to expose the gill slits (*g.s.*), gill rakers, and four opercula (*o.p.*). × ½.

On the under side of the front part of the head there is a transverse fold of skin, "gular fold," which is attached in front and free behind, where it overlaps the gill slits and bases of the gills. This fold is entire in the middle line, as seen in Fig. 3, in contrast with its decidedly emarginate outline, as seen in Baird's figures ('**59**, Figs. 1 *d*, 2 *c*) and in the Montana specimens.[1] The gular fold covers and hides four gill slits. The first one is directly behind it and in front of the first of the four gill arches. It differs from the other three slits by the absence of denticulations of the skin, reinforced by cartilage, and reminding one of the gill rakers of the sturgeon, which guard the passage through the other three slits. The arches are supported by a rod of cartilage which arches around

[1] But not in Baird, '**52**.

from the hyoid bone to the roof of the skull. The skin below the arches forms a thin flap, the operculum, which is continuous at its outer edge with the gill, a fleshy outgrowth running outward and backward. The gills are compressed at the base so as to be flattened vertically; but this decreases as you pass out on the gill, till at the tip it is flattened from above and considerably widened to a spatulate form. They are of different lengths, increasing as they go back, and the longest is considerably longer than the head. In all other forms they are no longer than the head, and in most they are decidedly shorter. And in all other forms they are lanceolate in outline and taper acutely at the tip.

The gills bear a tangled mass on the under side, or at the margins in the flattened distal part, composed of a great number of jet-black, long, and slender filaments, some of which attain a length of 11 mm. The filaments are actually much more numerous than is shown in the figures, forming an indiscriminate mass of hairy appearance all down the edge of each gill. These filaments, again, are unlike those of other forms. Thus in *S. gracilis* of Baird ('59) the filaments are broad, flat, short, and straight; here they are slightly flattened, but are extremely long and slender. In the Montana specimens these structures are more suitably indicated by the term "plates" and are 1 mm. wide by only 3 mm. long.

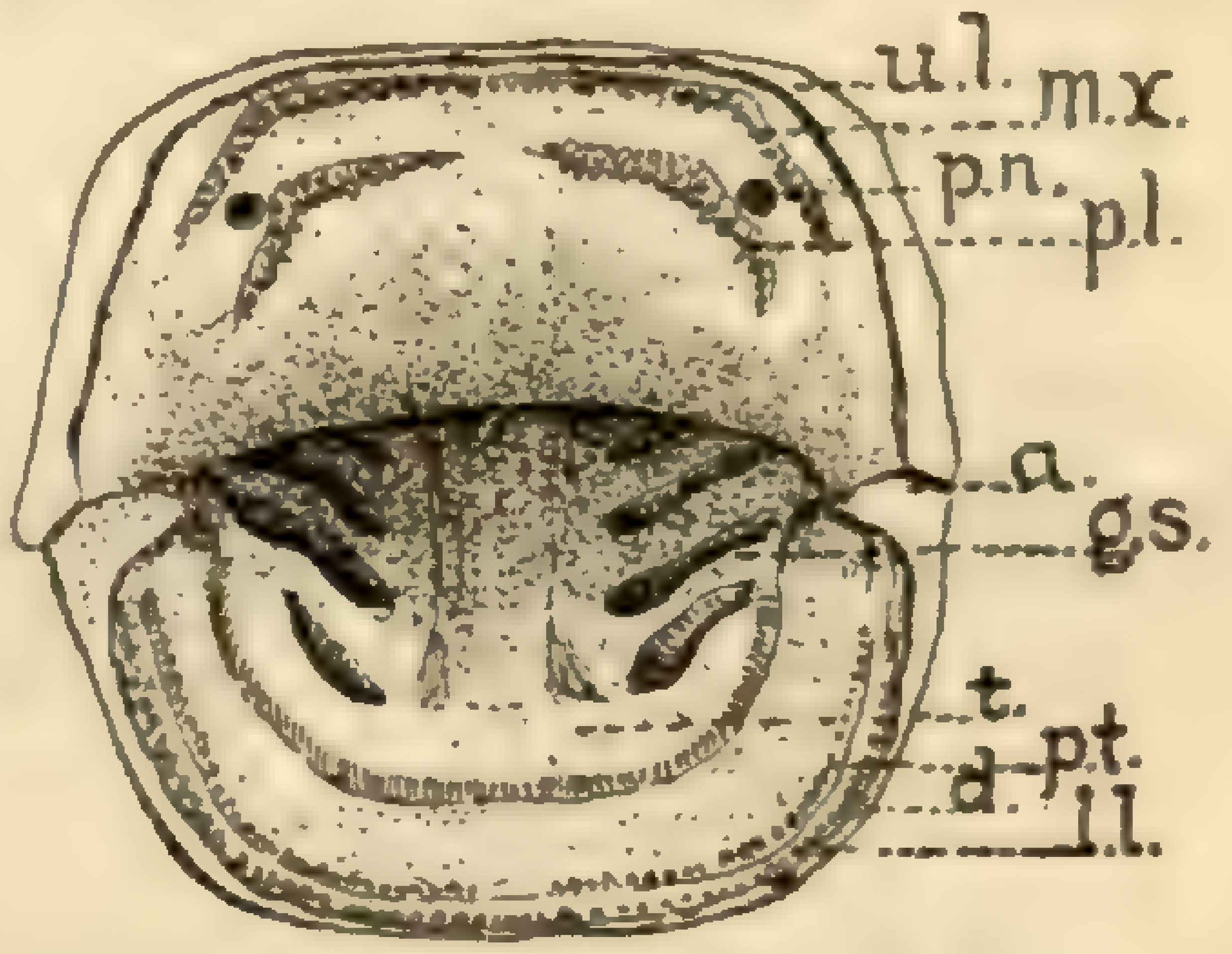

FIG. 4. — Mouth and throat chamber of Dakota axolotl — *a.*, angle of jaws; *d.*, dentary; *g. s.*, gill-arch; *ll.*, lower lip; *mx.*, maxillary teeth; *pl.*, palatine teeth; *p.n.*, posterior nares; *p.t.*, posterior row of teeth of lower jaw; *u.l.*, upper lip. × ½.

The mouth cavity is illustrated in Fig. 4. There are thin, slightly fleshy upper and lower lips. Directly behind the upper lip is a bony arch, bearing a limited number of small teeth, *mx.*, which are set close together and crowded so as to form, somewhat indefinitely, two rows. This arch is relatively much shorter than it is in the adult *A. tigrinum*, where the row of maxillary teeth reaches back nearly to the angle of the jaw, and very considerably posterior to the level of the posterior

nares. The palatine teeth are numerous and evident, and there is a decided bend in the palatine bones, in marked contrast with the feebler development of teeth in the adult *A. tigrinum*, where also the palatines are not so strongly bent as here. In the lower jaw the dentary also bears an indistinctly double row of well-marked teeth, and directly behind it there is another row of teeth (splenial ?), carried on a bony or cartilaginous support, which appears to be entirely distinct from the dentary, though in close relation with it. The posterior row is not complete in the middle line. The floor of the mouth is pierced by the gill slits, and the tongue is only feebly developed.

The trunk region is somewhat distended by the reproductive organs. Its wall is marked by the "costal grooves," as they are called by Cope ('89), consisting of light, narrow myocommata and darker broad myomeres. The number of myomeres included between the front and hind limbs is twelve, as in *A. tigrinum*. The proportion of the trunk to the post-abdomen is the same as in the adult *A. tigrinum*. The dorsal fin originates on the level of the second costal ring, some distance behind the head. The position of this point of origin in the Mexican axolotl and in Baird's siredons, as indicated in the figure in Stansbury's report, is close to the head, but in Tegetmeyer's figure and in the specimens from Montana the fin originates as in the Dakota specimen. The fin is not very high at any point, and in texture is not thin; in the Montana specimens the fin broadens out very much in the post-abdominal region, more so than in any other recorded forms, and is very thin, so that the branchings of the blood vessels are very evident.

The limbs are located here as usual, but the fore limb is shorter than in some of the allied forms, reaching only to the sixth myomere, while in the Montana axolotls I find that they reach the eighth myomere. The fingers are considerably flattened, and at their base the skin stretches across between them so as to produce a web; this result is further aided by the very broad and slightly flattened condition of the forearm. The same condition is noticeable in the hind limb. In the latter the typical number of toes, *viz.*, five, is found on the left side, but only four are present on the right; this number is abnormal.

The "tail," or post-abdomen, is compressed, and it is considerably less in cross-section than the trunk; this disparity is greater here than in adults. Its outline is unlike that of other axolotls and of the adult *A. tigrinum;* in them it gently tapers from the base; here it is almost parallel-sided till the tip is nearly reached, when the taper is rapid. In this point the tail is decidedly different from the Montana forms.

A complete dissection of the viscera has not been made, but enough has been seen by cutting through the body wall and pushing the parts aside to show that the organs generally are as in the adult salamander. This was seen to be true of the alimentary organs, the lungs, and the urogenital system. The lungs are fully developed on both sides. The specimen is a female, and the ovaries are fully ripe and contain the usual vast number of eggs, each having a diameter of about 2 mm. The oviducts are greatly twisted and dilated with albuminous material to be used in egg laying. These organs both agree in appearance with adult females of *A. tigrinum*, ready for spawning, which have been often met in the laboratory. The maturity of these organs and the simultaneous larval condition of so many other parts are convincing proof that the specimen is a true axolotl. It is not credible that the animal could have undergone transformation of its other parts before the eggs should have been laid.

The spawning season for Amblystoma is very early in the spring; often the spawn is found in the ponds while they are still frozen in places, and this specimen caught in the last of March was just in readiness for the spawning act. It is interesting to note here that some of the specimens from Montana are also in a condition of activity of the reproductive organs, as is shown by the recognition of Spermatozoa in the males, and ripe ova in the females. These facts are the only ones on record, so far as I am aware, going to prove that the American forms are like the Mexican axolotl, and in their native state reproduce while still larval in form.

Since this specimen is the only one of which we have any knowledge, it seems premature to speculate on its significance in connection with the axolotl question, and I have

intended at present only to record the facts about it. These, in brief, are a close general resemblance to *A. tigrinum;* a decided unlikeness to the hitherto recorded siredon larvæ of that species in the following particulars: the total size of the specimen, the shape of the gular fold, the size and shape of the gills, the number, size, and shape of the gill filaments, the proximity of the eyes to the snout, the coloration of the body, the length of the front limbs, the outline of the post-abdomen, the locality in which it is found. This decided divergence calls for a more complete study of the Amblystomidæ of that region, and this it is hoped will be made during the coming season.

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ST. PAUL, MINN., Feb. 3, 1900.

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THE FEMALE OF ECITON SUMICHRASTI NORTON, WITH SOME NOTES ON THE HABITS OF TEXAN ECITONS.[1]

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One of the most interesting problems confronting the student of ant life in subtropical and tropical America is the determination of the sexual forms of the foraging, or driver, ants (Ecitonini). These ants are known only from a study of the workers, as the corresponding male and female forms, which are so aberrant as to have been placed in different genera, have not been satisfactorily determined in any one of the known species. The state of our knowledge of the sexes of the Dorylides (including the African species of Dorylini) up to 1899 is summarized by Sharp in the *Cambridge Natural History*[2] as follows:

> The females of the Dorylides are amongst the rarest of insects and are also amongst the greatest of natural curiosities. Although worker and female ants are merely forms of one sex, — the female, — yet in this subfamily of ants they have become so totally different from one another in size, form, structure, and habits that it is difficult to persuade one's self they can possibly issue from similar eggs. In the insect world there are but few cases in which males differ from females so greatly as the workers of Dorylides do from the females, the phenomena finding their only parallel in the soldiers and females of termites; the mode in which the difference is introduced into the life of the individuals of one sex is unknown. . . .
>
> The specimens of female Dorylides that have been detected may, after fifty or sixty years of research, be counted on the fingers. As the greatest confusion exists in entomological literature owing to the forms of a single species having been described as two or three genera, the following summary of the principal names of genera of Dorylides may be useful:
>
> *Eciton* = the workers; *Labidus* = male: ♀ unknown.
> *Pseudodichthadia;* female only known, possibly that of *Eciton.*
> *Cheliomyrmex;* workers and soldiers only known.

[1] *Contributions from the Zoölogical Laboratory of the University of Texas.* Director W. M. Wheeler, No. 4.

[2] Vol. vi, pp. 179, 180.

Aenictus = male ; *Typhlatta* = worker ; ♀ unknown.
Rhogmus ; male ; female unknown (according to Emery the worker is very small and like *Alaopone*).
Anomma ; only worker known ; male probably a *Dorylus.*
Dorylus = male ; *Dichthadia* = ♀ ; *Alaopone* and *Typhlopone* = workers.

Until last year the only known insect that could be regarded as a female Eciton was the Pseudodichthadia, included in the above table. It was described by André as *P. incerta* in a paper which I have not seen. It has been supposed to be the female of *Eciton omnivorum* Ol (= *cæcum* Latr.),[1] "but his description and figure are imperfect and do not greatly support his idea of a connection between Eciton and Pseudodichthadia."[2]

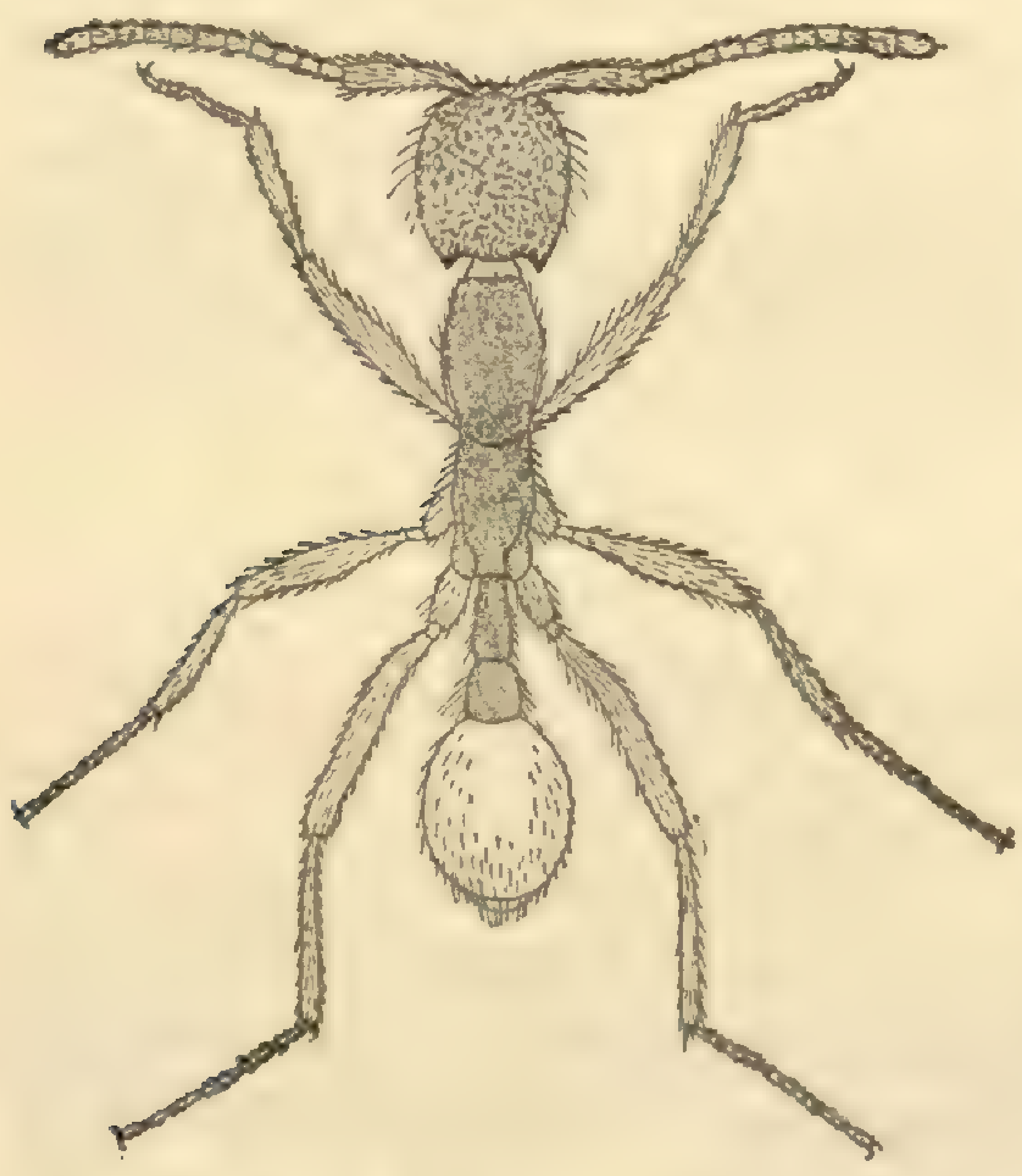

FIG. 1.—Sterile female, or worker, of *Eciton sumichrasti* Norton (length 4.5 mm.).

Professor Forel, while on a visit to the United States during the summer of 1899, discovered in North Carolina what is undoubtedly the female of *Eciton carolinense* Emery. He has drawn up a good description of the insect, but without a figure, in a letter to the Belgian Entomological Society.[3] In this article and in a paper by Wasmann[4] I find mention of the fact that Schmitt had previously (1894) taken this insect in the same region.

For some months past I have been engaged in a study of the nests of the species of ants which abound in the vicinity of Austin, Texas, the locality of the classical studies of McCook

[1] According to Emery (Beiträge zur Kenntnis der nordamerikanischen Ameisenfauna, *Zool. Jahrb.*, Abth. f. System, etc., Bd. viii, p. 258) the male of this form is *Labidus latreillei* Jurine (= *L. Sayi* Haldem).

[2] Sharp. *Loc. cit.*, p. 117.

[3] *Ann. de la Soc. Entomol. de Belgique*, tome xliii (1899), pp. 438–447.

[4] Ein neuer Gast von Eciton carolinense, *Deutsche Entomol. Zeitschr.*, Heft ii (1899), pp. 409, 410.

on the agricultural ant (*Pogonomyrmex barbatus* Smith). I had found several nests of *Eciton omnivorum* and *E. sumichrasti* under stones along the sloping banks of Shoal Creek, but in no case did these colonies comprise anything but workers, till quite unexpectedly, on the 30th of March, in a large nest of the latter species, I detected what may be described in words borrowed from Forel's description of the female of *E. carolinense*: "une longue et large bête aveugle et aptère, se mouvant lourdement avec son immense abdomen distendu au milieu des ☿." There could be no doubt that I had found the queen of the colony.

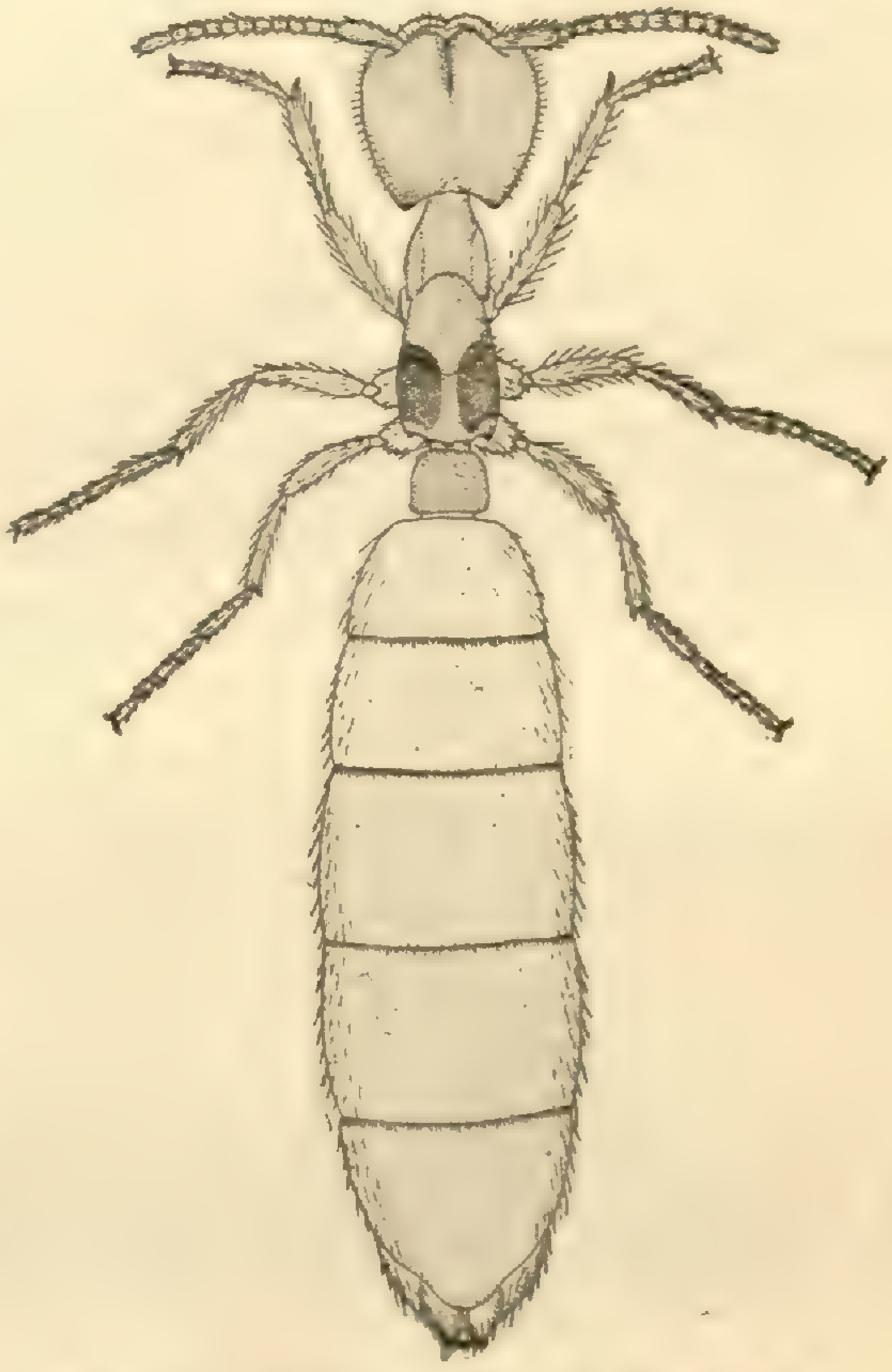

Fig. 2. — Young fertile female, or queen, of *Eciton sumichrasti* Norton.

A few days later (April 11) one of my students succeeded in finding another large nest of *E. sumichrasti* containing an even larger female. In this nest some of the workers were carrying larvæ and pupæ, and the queen was still producing eggs. As this female differs in several particulars from the first one captured, I insert brief descriptions of both, designating the former specimen as ♀*A*, the latter as ♀*B*. Both of these insects had the head and thorax more or less concealed by shining yellow mites, shaped like minute chelomorph beetles, with long yellow hairs projecting from their dorsal surfaces. These mites, represented *in situ* in the sketch of ♀*B* (Fig. 3), were sometimes either rapidly removed by the workers enveloping the queen or migrated of their own accord to the workers. I infer this from the fact that the queen would sometimes emerge from the swarm of workers glistening with these parasites, while at other times she would be found entirely free from them.

♀*A*. Length 13.5 mm. Light reddish brown, articulations of antennæ and legs and a large oblong blotch on either side of the metanotum, extending over the posterior third of the mesonotum, black. Surface of head, thorax, and abdominal pedicel subopaque, coarsely and rather densely punctate. Abdomen and legs shining, more finely and sparsely punctate. Body covered with delicate golden-yellow hairs, long on the legs and on the sides and tip of the abdomen, short and erect on the head.

Head large, swollen, subcordate above the clypeus, broader in front than behind; posterior angles rather prominent, but not acute as in the worker. Eyes vestigial like those of the ☿; ocelli absent. Mandibles slender, pointed, without distinct teeth. Down the middle of the head from the clypeus to the occiput runs a distinct furrow, deepest anteriorly. Antennal scape short, incrassated; funicle consisting of subequal joints, except the last, which is twice as long as any of the preceding. Legs short, tibiæ and femora compressed antero-posteriorly. Thorax slender, elongate, without any traces of wings; suture between the pronotum and mesonotum faint but distinct, metanotum broader than the mesonotum, both flattened dorsally and distinctly impressed along the median line. Posterior surface of thorax declivous, bearing on each side near its lower posterior corner a small but distinct tooth. Abdominal pedicel consisting of a single node which is nearly square, being somewhat broader than long, with its anterior somewhat shorter than its posterior edge, flattened dorsally and with a slight longitudinal impression in the median line.

♀*B*. Length 17 mm. Dark rufous brown, legs somewhat lighter, black spots on the metanotum inconspicuous, with indistinct contours. Surface of the head, thorax, and abdominal pedicel more coarsely and confluently punctate than in ♀*A*; the mesothorax somewhat transversely wrinkled.

Head proportionally smaller than in ♀*A*. Furrow down the middle of the mesonotum and metanotum and the abdominal pedicel much deeper. Abdomen with the exception of the first segment greatly enlarged, so that the dorsal and ventral sclerites are separated from one another by the tense interscleritic membrane. This is thin and transparent, but appears milk-white owing to the underlying eggs.

The differences between ♀*A* and ♀*B* seem to be due to a difference in age, the former being a young queen, — possibly not more than a year old, — the latter a much older individual. If this supposition is correct, and if the differences above noted are constant, it is probable that the ♀ Eciton exhibits a certain amount of postmetamorphic growth even in the thoracic and basal abdominal regions.

The similarity of the ♀ Eciton to the African Dichthadia, the reputed female of Dorylus, will be apparent to any one who compares the accompanying figures with Emery's figure of Dichthadia.[1] I also give a figure (Fig. 1) of the worker of *E. sumichrasti* for the sake of showing the remarkable differences between the fertile and sterile forms of the same sex. The single node in the abdominal pedicel of the female and the two nodes in the worker, characters which are often used in the taxonomic separation of whole families of ants, are here combined, not only in the same species, but in the same sex![2]

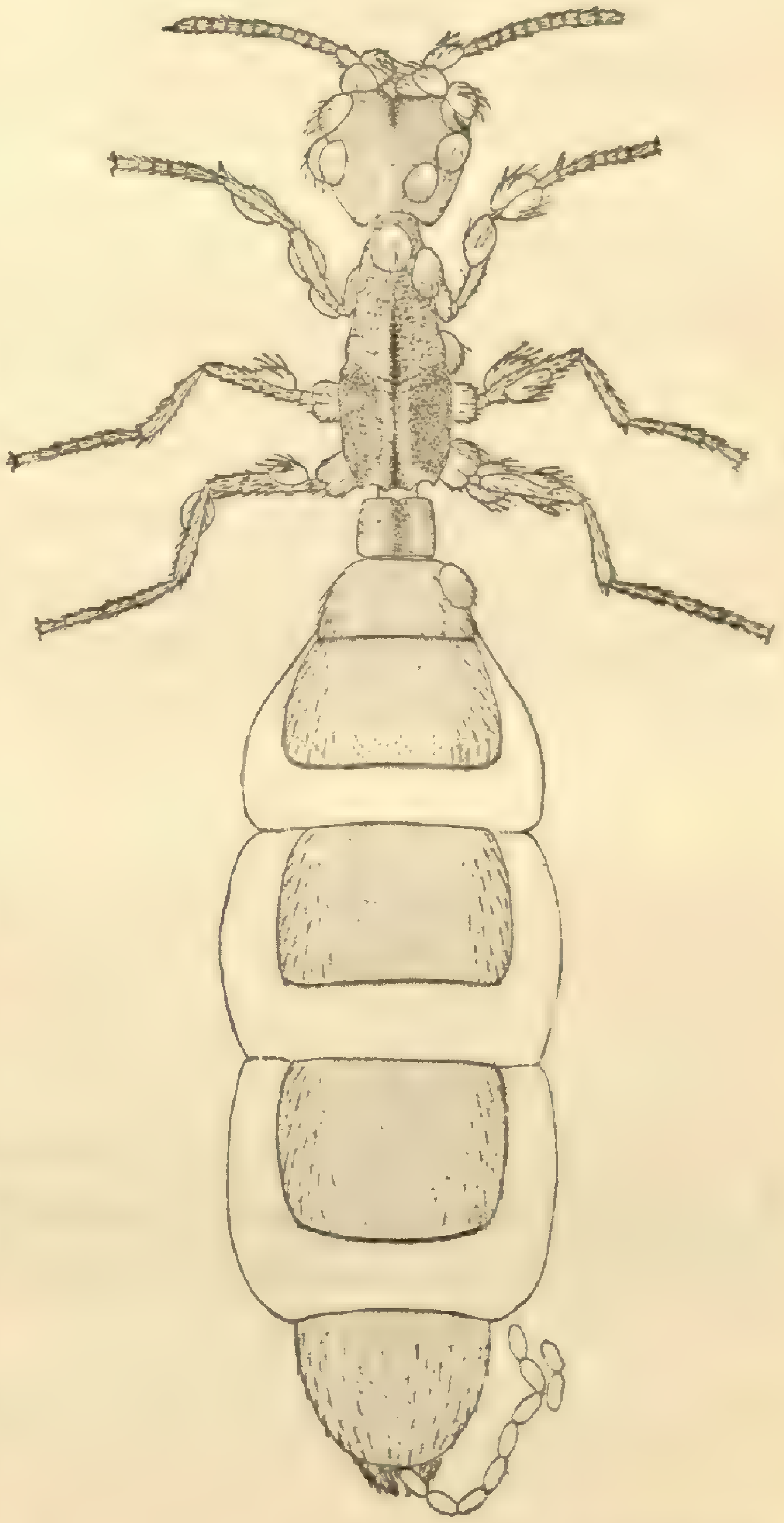

Fig. 3. — Old fertile female, or queen, of *Eciton sumichrasti* Norton, infested with mites. The insect was sketched during oviposition.

[1] Reproduced in Sharp's contribution to the *Cambridge Natural History*, vol. vi, p. 178, Fig. 79.

[2] The discovery of a single node in the pedicel of the female Eciton strengthens the already strong probability that Labidus, also with a single node, is the *bona fide* male of this genus.

The complete absence of any traces of wings in the female Dorylides also suggests many interesting problems for future investigation. The females must be fertilized either within the nest or during the organized marauding expeditions so characteristic of these ants.

Both the females in my possession were introduced at different times into an artificial nest (Janet pattern) of workers taken from an entirely different locality on Shoal Creek. They were very eagerly adopted and at once began to lay eggs. Female *A* laid very few, but ♀*B*, as was to be expected, produced a great number. Some of the workers were always clinging, with signs of great agitation, to the tip of her abdomen, and as soon as an egg would appear on the shovel-like hypopygium it would be seized and carried to another part of the nest. To this same spot other eggs were brought for some time. Later, however, they were distributed in little packets and carried continually in the mandibles of the workers as these marched round and round the nest in files, two and three abreast. The eggs are of the same shape and color as those of *Formica fusca*, but smaller.

During the past year I have seen three species of Eciton in the vicinity of Austin: *E. omnivorum* Ol (= *cæcum* Latr.), *E. sumichrasti* Norton, and what I take to be *E. californicum* Mayr. The last was taken only once by one of my students. Small colonies of *E. omnivorum* are not uncommon under stones, where they make burrows about a centimeter in diameter, usually leading directly into the ground. When the stone is lifted the ants show the greatest presence of mind (*sit venia verbo!*). They do not run about aimlessly and in disorder like other ants, but, notwithstanding the fact that they are absolutely blind, they at once organize themselves into columns and file down their burrows. The habits of this species thus appear to be the same as those of *E. carolinense* recently described by Forel (*loc. cit.*, p. 444):

Leur faculté instinctive de se concerter et de former des files dépasse absolument tout ce que j'ai vu chez d'autres fourmis. Vous jetez une poignée d'Eciton avec leur larves sur un terrain absolument étranger. En pareille circonstance, où les autres fourmis s'éparpillent en désordre et ont besoin

d'une heure ou plus (parfois moins) pour arriver à l'ordre, à réunir leur nymphes et surtout à reconnaître les environs, les Eciton se concertent, sans perdre une minute. En cinq minutes, ils ont formé des files distinctes de ☿ qui ne s'écartent pas les unes des autres, portent en partie les larves et les nymphes, et marchent en ligne assez précise, tâtant le terrain de leurs antennes, explorant tous les trous et fentes jusqu'à ce qu'elles trouvent une cavité à leur convenance. Alors le déménagement s'exécute avec un ordre et une rapidité étonnants. Les ☿ se suivent et se comprennent, comme par mot d'ordre, et en bien peu de temps tout est en lieu sûr. Pas question de transport mutuel ; c'est en plus précis le système des Tapinoma. Le fait est remarquable chez une fourmi aveugle, qui n'a absolument que ses antennes pour se diriger.

The colonies of *E. sumichrasti* are very much larger than those of *E. omnivorum*, and consist of thousands of individuals. They are found under large stones, often occupying cavities which they seem to dig themselves. They assemble in these cavities in compact masses, or swarms, which may be as large as a man's fist. These masses present a peculiar appearance, owing to the interlacing of the innumerable long, dark-red legs and antennæ, interspersed with the shining, lighter red abdomens. If such a mass be hastily scooped up and placed in a glass jar, the method of swarm formation may be watched at one's leisure. If the jar be held perpendicularly after being violently shaken till all the ants fall to the bottom, they will at once proceed to march up the sides of the jar in regular files. A few ants will soon come to rest, clinging to the glass, and will form the nucleus of a swarm which grows rapidly by additions from the moving columns. The ants are positively geotropic and therefore tend to hang head downwards when they cluster on one another. Such a swarm on the side of a jar is usually spindle-shaped, with perpendicular long axis. Frequently the swarm grows too large to be held in place by the claws of the individuals next to the glass, and the whole mass falls writhing to the bottom of the jar. The ants at once file up the walls of the jar and repeat the process. Occasionally the ants arriving at the top of the jar first will form the starting point for chains or festoons of ants, depending sometimes to a length of six inches in the form of a cord about a centimeter in diameter. In forming these chains, which remind

one of the pictures of prehensile-tailed monkeys crossing a stream, the insects make good use of their long legs and hooked claws. These chains may persist for hours, but are more often soon broken as their weight increases. If some loose earth be placed in the bottom of the jar, the ants will be seen to carry little pellets of it in their mandibles as they file up the sides of the vessel and to use these as points of attachment for their feet and jaws during swarm formation. Termites placed in the jar are at once devoured. Their heads and other fragments of their bodies are afterwards used by the ants for the same purpose as the pellets of earth.

It is evident that *E. sumichrasti* possesses in a very marked degree the power of swarming so characteristic of certain tropical Ecitons. The nomadic habits which have been observed in these forms were not observed in *E. sumichrasti*. During the winter and spring months, at least, the Ecitons I have observed occupy the same nest. This they probably continue to do till their young are raised. Belt has given an interesting description of the wandering and swarming habits of *E. hamatum* in Nicaragua.[1]

The Ecitons are singular amongst the ants in this respect, that they have no fixed habitations, but move on from one place to another, as they exhaust the hunting grounds around them. I think *Eciton hamata* does not stay more than four or five days in one place. I have sometimes come across the migratory columns. They may easily be known by all the common workers moving in one direction, many of them carrying the larvæ and pupæ carefully in their jaws. Here and there one of the light-colored officers moves backward and forward directing the columns. Such a column is of enormous length, and contains many thousands if not millions of individuals. I have sometimes followed them up for two or three hundred yards without getting to the end.

They make their temporary habitations in hollow trees, and sometimes underneath large fallen trunks that offer suitable hollows. A nest that I came across in the latter situation was open at one side. The ants were clustered together in a dense mass, like a great swarm of bees, hanging from the roof, but reaching to the ground below. Their innumerable long legs looked like brown threads binding together the mass, which must have been at least a cubic yard in bulk, and contained hundreds of thousands of individuals, although many columns were outside, some bringing in

[1] *The Naturalist in Nicaragua*, pp. 24–26. London, 1888.

the pupæ of ants, others the legs and dissected bodies of various insects. I was surprised to see in this living nest tubular passages leading down to the center of the mass kept open just as if it had been formed of inorganic materials. Down these holes the ants who were bringing in booty passed with their prey. I thrust a long stick down to the center of the cluster, and brought out clinging to it many ants holding larvæ and pupæ, which probably were kept warm by the crowding together of the ants.

The workers of the Texan species of Eciton have a very disagreeable odor unlike that of other ants. It closely resembles the vile odor of the neuropteron Chrysopa. The females of *E. sumichrasti*, on the contrary, have a mild, pleasant odor.

The males of Eciton, formerly described as species of Labidus, are frequently taken about the electric lights in dwellings and in the streets of Austin. I have seen three species, but two of these, from their size and coloration, can hardly belong to any of the above-mentioned species of Eciton, so that the workers of at least two more species have not yet been found in this vicinity.[1]

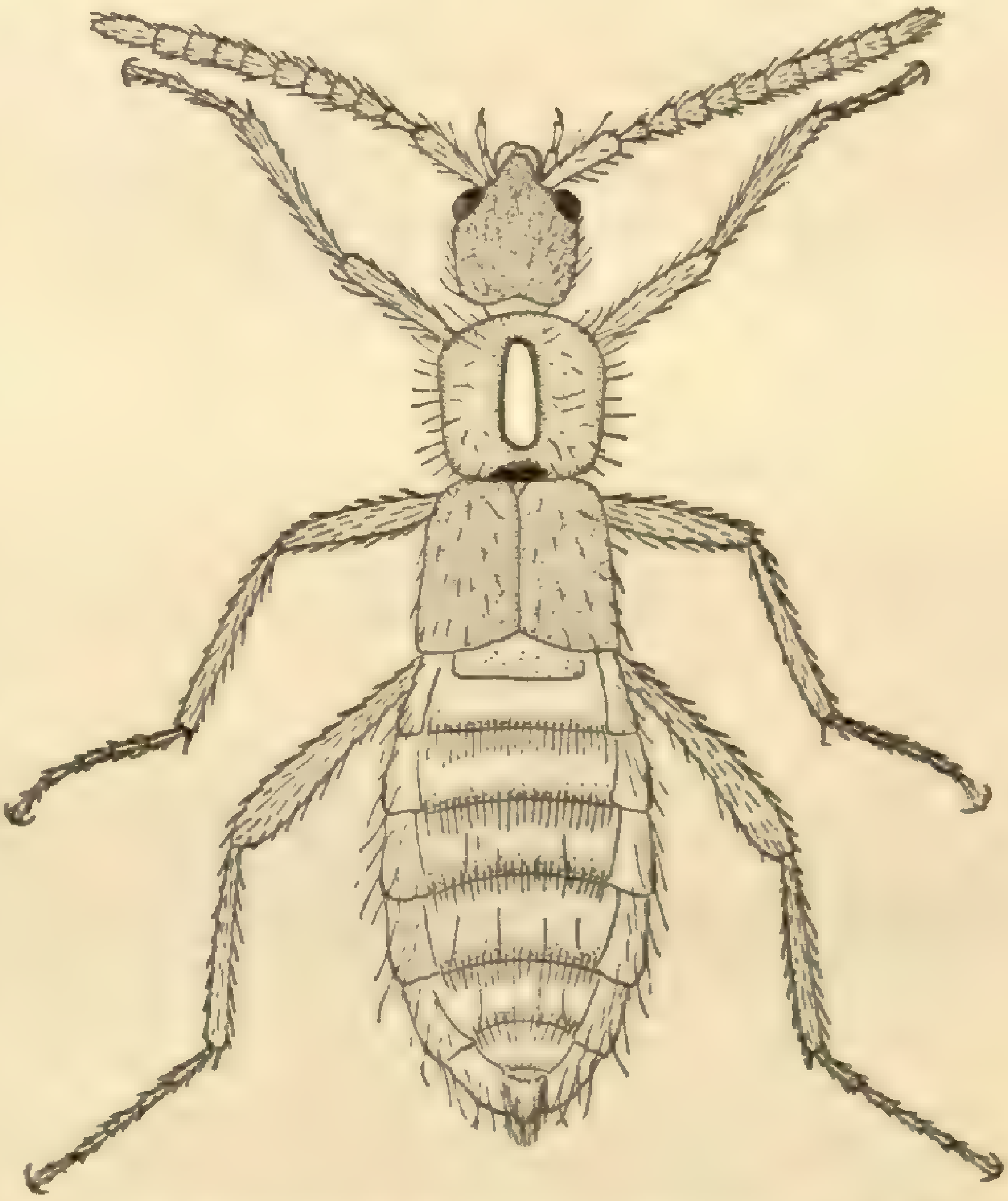

FIG. 4. — Ecitophilous staphylinid beetle occurring in the nest of *Eciton sumichrasti* Norton.

In conclusion some mention may be made of a few myrmecophiles encountered in the nests of Eciton. With *E. omnivorum* occurred a few specimens of a small histerid beetle (presumably *Echinodes setiger* Lec.). The peculiar ectoparasitic mite referred to above may also be included among the ecitophiles. Of greater interest is a small staphylinid beetle (Fig. 4), 2.75 mm.

[1] Cresson (Synopsis of the Hymenoptera of America, North of Mexico, *Trans. Amer. Ent. Soc.*, Suppl. Vol., Phila. (1887), p. 259) enumerates six species of Labidus as occurring in Texas. If these are really distinct species, there must be at least an equal number of species of Eciton in the State.

long, which is so much like a small worker, *Eciton sumichrasti*, that I did not notice it in the artificial nest till the ants had been under my observation for a month! One morning I happened to see it as it was marching around the nest in the files of the Ecitons. The movements of its legs and antennæ were precisely like that of its hosts. This resemblance extends also to its size, coloration, and the character of the surface of its body. Its head, thorax, and elytra are opaque, dark red, rather irregularly punctate, and furnished with a few scattered hairs. The abdomen is smooth and shining, of a lighter red color, widened towards the tip, and covered with longer, denser hairs than the remainder of the body. The eyes are well developed. The antennæ show a decided resemblance to those of the ant. The most striking character, however, is a very deep, elongate elliptical depression in the middle of the pronotum. The bottom of this depression seems to be formed by a white membrane. It is difficult to assign a function to this singular structure, unless it be the orifice of a huge gland that may secrete some substance relished by the Ecitons. During life the broadened tip of the shining red abdomen is bent up after the manner of staphylinids, and the resemblance of the insect to a worker Eciton becomes even more striking.

Wasmann has given an excellent account of the ecitophilous Staphylinidæ of Brazil.[1] In two more recent papers he describes a couple of staphylinids living with *Eciton carolinense*.[2] In his former contribution Wasmann distinguishes a number of ecitophilous genera (Ecitomorpha, Ecitonides, Mimeciton, Ecitonilla), which comprise some very remarkable mimics of the Ecitons with which they live. The form taken by myself is probably the representative of a new genus and is an additional case of mimetic adaptation somewhat less perfect than the genera described by Wasmann. It is, nevertheless, an admi-

[1] Die Ameisen- und Termitengäste von Brasilien, I. Theil, *Verh. k. k. Zool. Zoot. Gesell. Wien.* (Jahrg. 1895) pp. 1–45, 7 Abbild.

[2] Ein neuer Ecitongast aus Nord-Carolina, *Deutsche Entomol. Zeitschr.* (1897), Heft ii, pp. 280–282; and Ein neuer Gast von Eciton carolinense, *Deutsche Entomol. Zeitschr.* (1899), Heft ii, pp. 409, 410. The species are Ecitonüsa Schmitti, Wasm. und E. Foreli, Wasm.

rable illustration of the truth of some of Wasmann's remarks concerning these cases of mimicry. Since the Ecitons are blind, the color of the ecitophiles is of no consequence and may differ from that of the ants, — although in the present case there is great similarity even in coloration, — but the form and surface sculpture of the guest insect are of the greatest importance. Wasmann believes that the resemblance in sculpture between the staphylinids and their hosts — rough beetles living with the opaque species of Eciton, and smooth beetles with shining species of the ant — enables the former to prey on the eggs and larvæ of the Ecitons or to share their booty without being suspected as aliens. It is, indeed, quite probable that we have here a new and elsewhere unknown form of mimicry — a deception of the sense of touch which must be extraordinarily keen in these blind ants.

The University of Texas,
Austin, April 5, 1900.

POSTSCRIPT.

Since the above account was written it has been possible to make a few additional observations of interest on our Texan Ecitons. The insect which I designated as ♀ *B* died May 18, apparently of exhaustion, after depositing nearly all her eggs. ♀ *A* continued to live in the nest and to produce a few eggs from time to time. On April 20, when I disturbed the clustered workers, I was dumfounded to find them covering also another queen intermediate in length and coloration between ♀ *A* and ♀ *B*! Now this queen, which may be called ♀ *C*, could not possibly have existed as an insect larger than the largest workers (4.5 mm. long) among the thousand or more collected and placed in the artificial nest March 10. Soon after the colony was taken it was kept for about two weeks in a glass jar and had been the subject of numerous experiments on the clustering habit. A large insect, 16 mm. long and with shining white bands on the abdomen, could not have escaped my attention like the small mimetic ecitophile above described. Her presence in the colony can only be explained on the assumption that she was developed within the nest during less than a month from an insect closely resembling a worker in size and appearance. The workers must have been feeding her abundantly, notwithstanding their

devotion to the two introduced queens. Careful comparison of the largest workers with the ♀ of *E. sumichrasti* will show that there is nothing transcending the possibilities of insect development in supposing that a worker could be developed into a queen. This could, perhaps, be accomplished by a certain amount of postmetamorphic growth with an ecdysis or two, but the differences are still too great to justify us in drawing this conclusion from circumstantial evidence. During the coming year it may be possible to solve this interesting problem suggested by the sudden appearance of ♀ *C* in an artificial nest.

In the beginning of May my artificial colony showed signs of demoralization and decay. The eggs laid by ♀ *A* and ♀ *B* had been devoured and the workers were dying rapidly. ♀ *A* and ♀ *C* were killed and preserved May 12, as I had no hopes of raising the males.

Very recently I have succeeded in finding several colonies of *Eciton omnivorum*. One of these, discovered under some large stones May 4, was very large and flourishing, but it contained no queen, larvæ, or pupæ. There were, however, dozens of callow workers of different sizes. This may serve as a clue to finding the still unknown ♀ of this widely distributed species, since it indicates that the breeding season is earlier than that of *E. sumichrasti* — possibly in December or January.

E. sumichrasti was observed on the march May 1. May 2 I saw a black Eciton (near *E. Californicum*, but probably undescribed) moving along a path in double and triple files. These dates are here recorded because they seem to indicate the time when the Ecitons leave their temporary winter quarters to resume their marauding expeditions.

AUSTIN, May 20, 1900.

ON THE LINNÆAN GENERA MYRMECOPHAGA AND DIDELPHIS.

JAMES A. G. REHN.

I. Myrmecophaga.

In the tenth edition of the *Systema Naturæ*, Linnæus describes three species under the generic name Myrmecophaga, *i.e.*, Didactyla, Tridactyla, and Tetradactyla. Of these three, two have since been placed in new genera: Didactyla in Cyclopes (1821), and Tetradactyla in Uroleptes (1830).

The remaining species, Tridactyla, is characterized as having three toes on the manus and four on the pes, and two pectoral and six abdominal mammæ.

The plates referred to in Seba's work are not identifiable, but the reference of Ray's (*Quad.*, p. 241) quoted refers to the great ant-bear, and it states positively that the animal in question had four toes on the manus.[1] The latter part of the Linnæan description seems to refer to the great ant-bear, except the statement that it climbs trees. The habitat is *America meridionali.*

This name is thus seen to cover a composite animal, one combining some points of the great ant-bear, and the Tamandua (there described as *M. tetradactyla*), with a number of digits and mammæ present in none of the group of ant-eaters, and it should be thrown out of consideration.

The type of the genus Myrmecophaga is, therefore, by elimination *M. tetradactyla*, Didactyla having been separated nine years before.

In the twelfth edition Linnæus recognizes four species of this genus — *M. didactyla*, *M. tridactyla*, *M. jubata*, and *M. tetradactyla*. *M. jubata* possesses a short description, with sev-

[1] This Linnæus seems to have noticed later, and in the twelfth edition he transferred this reference from Tridactyla to Jubata.

eral references[1] which relate pointedly to the large, bear-like, bushy-tailed ant-eater, popularly known as the great ant-bear or great ant-eater. The habitat given is *Brasilia, Cap. b. spei.* The description of *M. tridactyla* in this edition is enlarged, and brings in more points belonging to *M. jubata*, but it retains all its old references but one, and includes two more — Brisson's *Quad.*, p. 27, and Bout. *Java*, p. 320, the latter of which I cannot examine. Brisson's description shows us the same beast of mixed character as above. The habitat, according to Linnæus, is now *India orientali.*

As *M. jubata* is generically distinct from *M. tetradactyla*, and no old name being available, I propose the name "Falcifer."[2]

The species of Myrmecophagidæ, therefore, would stand as follows:

Cyclopes Gray, 1821.

C. didactylus (Linnæus).

Myrmecophaga Linnæus, 1758.

M. tetradactyla Linnæus.
M. tetradactyla straminea (Cope).
M. longicaudata Wagner.
M. sellata Cope.

Falcifer, Rehn, 1900.

F. jubata (Linnæus).

II. Didelphis.

Under this generic name in the tenth edition are described five species, *i.e.*, Marsupialis, Philander, Opossum, Murina, and Dorsigera. Of these, three have been since separated generically; Philander becoming *Philander philander* (1808), Opossum becoming *Metachirus opossum* (1854), and Murina becoming *Marmosa murina* (1821). The species Dorsigera is a synonym of Murina, and Marsupialis is unrecognizable (see Alston, *Biol. Centr. Amer.*, p. 196, footnote, and Allen, *Bull. Amer. Mus. Nat. Hist.*, Vol. IX, p. 43).

[1] Two of these references are inaccessible to the writer.

[2] From *falx* + *fero*, 'sickle-bearing,' referring to the sickle-shaped claws of the fore feet.

The type of the genus Didelphis is, therefore, the last one removed — *D. opossum*.[1]

The large opossums formerly called Didelphis require a name, and the oldest one available is Sarigua Muirhead, with *S. virginiana* as the type. The complete reference is *Sarigua* Muirhead, *Brewster's Amer. Edition Edinburgh Encyclopædia*, Vol. XII, Part II, p. 505, 1819. The writer wishes to thank Dr. T. S. Palmer, of Washington, for calling his attention to this name.

The nomenclature of the opossums is in a very unsatisfactory condition, and the group is much in need of a revision, with a large amount of material for examination.

The recognized Linnæan species stand at present as :

Philander philander (Linnæus).
Didelphis opossum Linnæus.
Marmosa murina (Linnæus).

The large opossums should stand as :

Sarigua karkinophaga (Zimmermann).
Sarigua virginiana (Kerr).
Sarigua virginiana pigra (Bangs).
Sarigua virginiana californica (Bennett).
Sarigua aurita (Wied).
Sarigua azaræ (Temminck).

The species of *Didelphis* (= *Metachirus* Burmeister) stand as follows :

Didelphis opossum Linnæus.
Didelphis nudicaudata E. Geoffroy.
Didelphis crassicaudata Desmarest.

Acad. Nat. Sciences, Philadelphia,
March 24, 1900.

[1] Some hold that the *opossum* is not determinable, but the plates in Seba's work, referred to by Linnæus, though poor, are recognizable.

KARPINSKY'S GENUS HELICOPRION.

A REVIEW.

C. R. EASTMAN.

It is a significant and decidedly unwelcome truth that not one in one hundred essays on paleontological subjects receives anything like the elaborate care and finish which Dr. Karpinsky,[1] the Director of the Imperial Russian Geological Survey, has bestowed upon the remarkable ichthyodorulites which he describes under the name of "Helicoprion." Within the compass of 110 pages, enriched by seventy-two text-figures and four quarto plates, the subject is treated from all possible standpoints — historical, geological, chemical, histological, and biological. The result is a very gratifying addition to the knowledge of Palæozoic fishes.

Helicoprion is a fitting title for the peculiar "spiral saws," coiled in three and a half whorls and armed with upwards of 150 sharp teeth, which have recently been discovered in the Permo-Carboniferous (Artinsk Series) of the government of Perm. Although ammonitic in outward appearance, inspection shows these bodies to be of elasmobranch nature, the nearest allied structures being found amongst the Edestidæ. A complete summary of the literature of Edestidæ is given in the first twenty pages, with text-figures of all the more important species that have been described. Next follows a discussion of the stratigraphic position of the Russian specimens, and finally a minute account of their form, structure, and general nature. At the end the results of the investigation are tabulated under sixteen different headings, and a restoration is attempted showing the imaginary position occupied by the spiral during life of the creature. Few will be prepared to admit, however, that

[1] Karpinsky, A. Ueber die Reste von Edestiden und die neue Gattung Helicoprion, *Verh. k. russ. min. Ges. St. Petersburg*, Ser. 2, Bd. xxvi, No. 2, 1899.

this highly fanciful sketch can be taken seriously, and, therefore, the least said about it the better.

Of the two leading theories as to the position in the body of Edestus "spines," the first ascribes them to the jaws of a shark or skate, and the other to the median line of the back, some distance in advance of the dorsal fin or in a cephalic position. Dr. Bashford Dean [1] confidently asserts that the evidence of *Edestus lecontei* leaves no room to doubt that "the spine had its origin as a metameral structure whose basal portion lay within the integument, and traversed longitudinally a number (seven at least) of body segments." This supposed metameral origin of Edestus is still more strongly insisted on by the same author in his *Fishes, Living and Fossil* (pp. 28–30). On the other hand, those who deny that these structures are dermal defenses and regard them as part of the dentition are impressed by the close similarity in form and structure of the enameled denticles as compared with ordinary sharks' teeth, especially those of Carcharodon and certain Palæozoic genera. As it is difficult to conceive of such unwieldy, bilaterally symmetrical bodies being located within the mouth cavity, they have been compared by the elder Agassiz with the rostrum of swordfishes, and by Miss Hitchcock with the symphysial dentition of Onychodus. Dr. Karpinsky's conclusion that the spiral was external and attached to the upper jaw in the manner shown is based on the following considerations: (1) Helicoprion belongs undoubtedly to an elasmobranch; (2) the bases of all the segments ("teeth") of the spiral were imbedded in the soft parts of the fish; (3) the spiral must have been situated in the median vertical plane of the fish; (4) the whole of the spiral, except the large end, must have been exposed; and (5) the large size of the spiral (26 cm. in diameter) renders it highly improbable that it could have been contained within the mouth cavity.

Dr. A. S. Woodward,[2] in a review of Karpinsky's memoir, likewise admits that "the conception of a gigantic shark armed in both jaws with several series (whorls) of teeth, like those

[1] *Trans. New York Acad. Sci.*, vol. xv (1897), p. 68.

[2] *Geol. Mag.*, vol. vii (1900), p. 36.

now described under the name of Helicoprion, is, indeed, sufficiently startling." Nevertheless this distinguished expert brings forward considerable evidence in favor of the view that Edestus and Helicoprion should be looked upon as Palæozoic sharks "with sharp, piercing teeth, which were never shed, but became fused into whorls as the animal grew." The question, then, as to whether these objects are segmented spines or teeth would seem to remain as puzzling as ever, in spite of the abundance of new light thrown on their structure by Karpinsky's studies. Analogy alone is insufficient to settle the problem; we must have the positive evidence that only fresh material can supply. Should several whorls, or "spines," be discovered in natural association, that is, belonging to one individual, it would be a fatal argument against their being dermal defenses, and we should have to look upon them as actual, veritable teeth, as suspected by Woodward.

FIG. 1. — *Sandalodus laevissimus.* N and W. Keokuk limestone, Keokuk, Iowa. Posterior dental plate of left mandibular ramus. × ⅔.

As far as analogy goes, however, no one can deny that there are a number of points in common between the segments of Helicoprion and various forms of cochliodont and petalodont dentition, where the earlier formed teeth are permanently retained, and there are all degrees of fusion and coiling. Karpinsky himself calls attention to certain points of similarity in the structure of Janassa, Glossodus, and Helodus, and since his memoir appeared an important paper on the dentition of the first-named genus has been published by Jaekel,[1] which calls to mind more forcibly than ever the resemblance to a por-

[1] Jaekel, O. Ueber die Organisation der Petalodonten, *Zeitschr. d. d. geol. Ges.*, Bd. li (1899), pp. 258–298. *Cf.* Text-fig. 1, p. 265.

tion of the whorls of Helicoprion. As for *Helodus coxanus*, cited by the Russian director, it may be remarked that, after a study of the type specimen (now in the keeping of the U. S. National Museum) in connection with a large series of dental plates of *Cochliodus latus* from the same horizon, the reviewer is satisfied that they were associated in one and the same mouth. *H. coxanus* is, accordingly, but another name for one of the several arched series of knob-like teeth situated in advance of the large pair of dental plates in the upper and lower jaws of *Cochliodus latus*.

A very curious case of coiling among cochliodonts which has not been previously reported occurs in *Sandalodus lævissimus*, which accompanies *Cochliodus latus* in the Keokuk limestone of Iowa and Illinois. The initial portion of the large posterior dental plate is wound upon itself one and a half times before expanding into the functional grinding surface characterizing the adult, and in *Deltodus undulatus* from the Burlington limestone a like condition obtains on a somewhat smaller scale. These instances deserve notice, when we consider the variety of evidence it is necessary to take into account before passing judgment on the extremely problematical nature of the Edestidæ. In Fig. 1 is shown one of the most perfect examples of Sandalodus ever discovered, and its bearing on the present subject will be evident from inspection.

SYNOPSES OF NORTH-AMERICAN INVERTEBRATES.

XI. The Catometopous or Grapsoid Crabs of North America.

MARY J. RATHBUN.

One of the most familiar forms of the Catometopa is the common ocypode, or sand crab, which lives on the beaches in abundance south of New England. It digs holes in the sand, occasionally retreating to the water when frightened. It is protected by its color, resembling that of the sand, and by the swiftness of its movements.

The fiddlers, which may be recognized by the extraordinary development of one of the claws of the male, are represented by many species which burrow in sand beaches or in muddy banks of streams and ditches in the salt marshes, while at least one species, *Uca minax*, extends up rivers quite to fresh water.

Of the Grapsidæ, the *Sesarma reticulatum* also burrows in muddy banks. Its congener, *S. cinereum*, is sometimes known as the "wood crab," from its occurrence under logs and drift and about wharves, wood piles, etc. On the Pacific coast, the species of Hemigrapsus are abundant under stones and on mud flats in salt or brackish water.

The common land crab of tropical America and the West Indies, *Cardisoma guanhumi*, occasionally makes its appearance in Texas. It is the only member of the Gecarcinidæ which comes within the limit of this paper.

The Pinnotheridæ are readily known by their small size, small eyes, often soft or membranaceous integument, and commensal habit, dwelling often in the shells of bivalve mollusks, in the tubes of annelids, or on sea-urchins. The best known species is the common oyster crab, *Pinnotheres ostreum*, which is often cooked and eaten with oysters.

The Palicidæ, some of which appear in our list, are small anomalous forms, inhabitants, chiefly, of warm waters or of considerable depths. Four species are known to occur either in the Gulf or in the Cape Hatteras region in less than one hundred fathoms.

TRIBE CATOMETOPA OR GRAPSOIDEA.

Carapace broad anteriorly, often subquadrate, sometimes subglobose, truncate or arcuate anteriorly, but not rostrate. Front bent downward. Epistome short, often almost linear. The pairs of branchiæ are usually fewer than nine in number; the efferent channels open at the sides of the endostome. The male verges are inserted either in the sternal plastron, or in the basal joints of the last pair of legs, thence passing through channels in the sternum beneath the pleon.

KEY TO THE FAMILIES OF THE TRIBE CATOMETOPA.

A. Carapace hard and firm. Front, orbits and eyestalks not very small. Buccal frame quadrate anteriorly.
- *B*. Last pair of feet not remarkably reduced.
  - *C*. Carapace moderately convex or depressed; branchial regions not greatly dilated.
    - *D*. Third maxillipeds with the fifth joint articulated at the front inner angle usually. Front of moderate width or very narrow. Eyestalks often greatly elongate OCYPODIDÆ Leach
    - *D′*. Third maxillipeds with fifth joint articulated at apex or front outer angle of fourth. Front usually broad. Eyestalks of moderate size GRAPSIDÆ Milne Edwards
  - *C′*. Carapace very convex, especially dilated over and in front of the branchial regions; antero-lateral margins entire or subentire, and strongly arcuate. Terminal joint of walking legs often armed with longitudinal rows of spines GECARCINIDÆ Milne Edwards
- *B′*. Last pair of feet remarkably reduced . . . PALICIDÆ Rathbun

A′. Carapace often more or less membranaceous. Front, orbits and eyestalks usually very small. Buccal frame arcuate anteriorly. Of small size . . . . PINNOTHERIDÆ Milne Edwards

KEY TO THE GENERA OF THE FAMILY OCYPODIDÆ.

A. Carapace trapezoidal or quadrate. Eyestalks often elongate.
- *B*. Lateral margins entire.

C. Eyestalks stout. Chelæ in male somewhat unequal Ocypode
C'. Eyestalks slender. Chelæ in male extremely unequal . Uca
B'. Lateral margins toothed.
C. Lateral margins parallel or nearly so . . . Euchirograpsus
C'. Postero-lateral margins posteriorly converging . Euryplax
A'. Carapace with antero-lateral margins arcuate. Eyestalks of moderate length.
B. Carapace with margins spinous . . . . Geryon
B'. Carapace with margins feebly dentate . . . . Speocarcinus

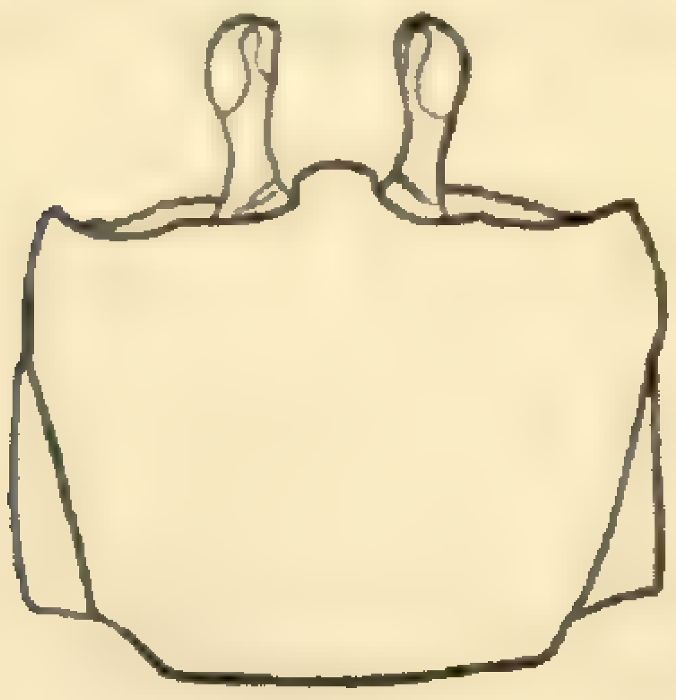

Fig. 1. — Ocypode albicans, carapace.

Fig. 2. — Ocypode albicans, chela.

THE SPECIES OF OCYPODIDÆ.

Genus Ocypode Fabricius . . . . *O. albicans* Bosc, *MSG*
= *O. arenaria* Say

Genus Uca Leach.

Key to Species.

A. Inner surface of palm of large cheliped without an oblique ridge.
B. Carapace very short, broad, and convex. Abdomen of male wide, increasing noticeably in width towards proximal end
U. subcylindrica (Stimpson), *G* [1]
B'. Carapace of moderate width and convexity. Abdomen of male of moderate width, its sides subparallel
U. pugilator (Bosc), *MSG*
A'. Inner surface of palm with an oblique ridge.
B. Oblique ridge terminating at carpal cavity.
C. Front (between the eyes), very shallow and broad. Claws with red spots at the articulations
U. minax (Le Conte), *MSG*
C'. Front narrow, its sides oblique.
D. Eyebrow (or surface between the orbit and the dorsum) nearly vertical, scarcely visible in a dorsal view. Space on inner surface of palm, between carpal cavity and dactylus, coarsely granulate
U. pugnax (Smith), *MSG*
D'. Eyebrow inclined, visible in a dorsal view. Space between carpal cavity and dactylus finely granulate
U. pugnax rapax (Smith), *G*

[1] Texas.

B′. Oblique ridge not terminating at carpal cavity, but continued by an angular turn to near the superior margin.

C. A tooth or spine on the inner surface of the carpus of the large cheliped. Ridge on inner surface of palm strongly produced . . . . *U. spinicarpa* Rathbun, sp. nov.,[1] *G*

C′. No tooth nor spine on inner surface of carpus.

D. Superior surface of palm turned abruptly at right angles with outer surface, and forming a flat or concave surface *U. coloradensis* Rathbun, mouth of Colorado River

D′. Superior surface of palm rounding gradually into outer surface . . . . *U. gracilis* Rathbun, *D*

Genus Euchirograpsus Milne Edwards *E. americanus* A. Milne Edwards, *S*

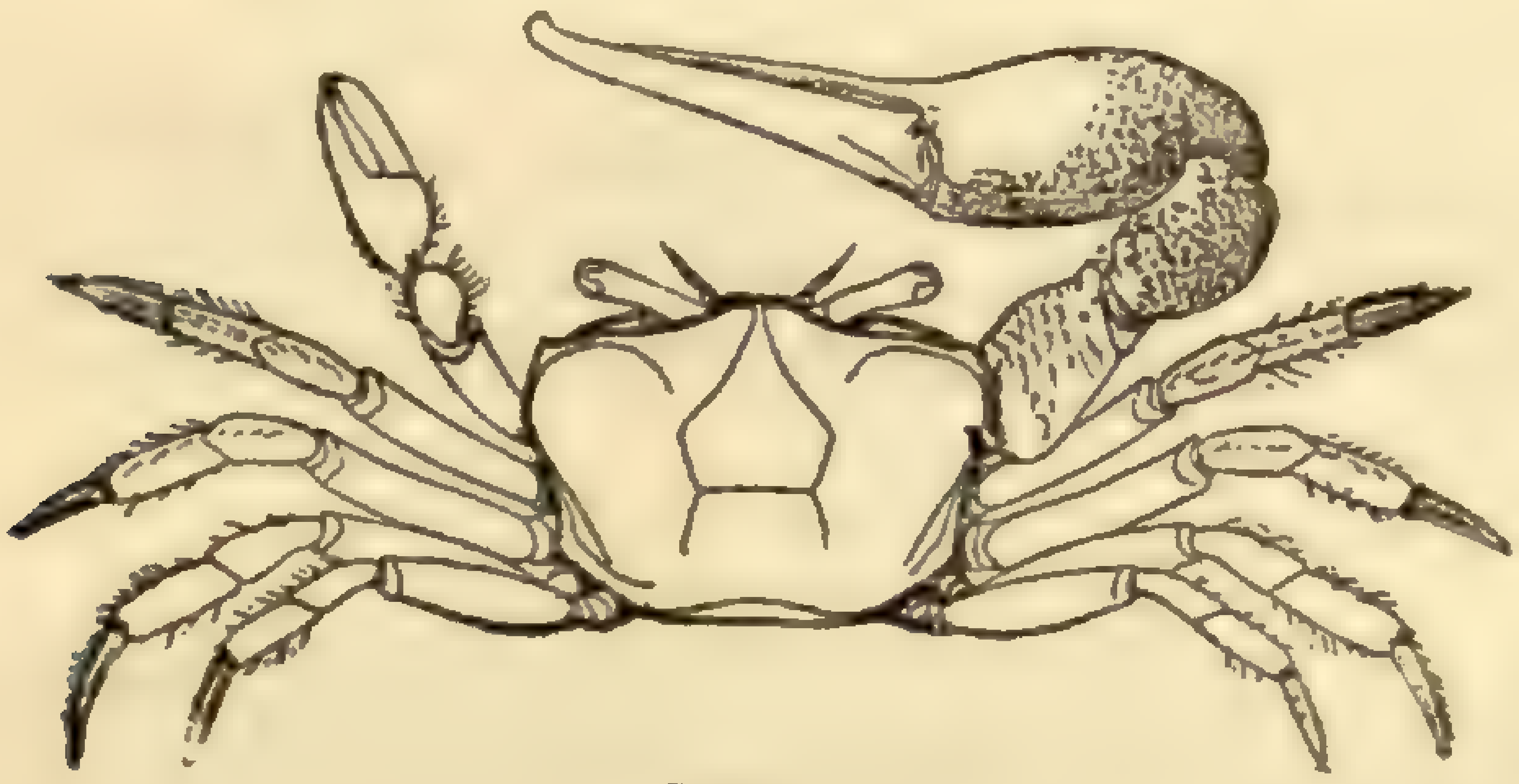

FIG. 3.

FIG. 4.

FIG. 5.

FIG. 3. — Uca pugilator. FIG. 4. — Uca pugilator, inner side of large chela.
FIG. 5. — Geryon quinquedens, carapace.

Genus Euryplax Stimpson . . . . *E. nitida* Stimpson, *G*
Genus Geryon Krøyer . . . . *G. quinquedens* Smith, *NM*

Genus Speocarcinus Stimpson.

Key to Species.

A. Lateral margin of carapace with three notches *S. carolinensis* Stimpson, *S*

A′. Lateral margin of carapace with two notches *S. californiensis* (Lockington), *D*

THE SPECIES OF GECARCINIDÆ.

Genus Cardisoma Latreille . . . . *C. guanhumi* Latreille, *G*

KEY TO THE GENERA OF THE FAMILY GRAPSIDÆ.

A. Antennæ covered by the front.

B. External maxillipeds without a piliferous ridge.

C. Carapace as long as or longer than broad . . . . Planes

C′. Carapace considerably broader than long.

[1] Type, U. S. Nat. Mus., No. 22,183, Galveston, Texas; Boll, collector.

D. External maxillipeds with a wide rhomboidal gape . . . Pachygrapsus
D'. External maxillipeds with a narrow gape . . . Hemigrapsus
B'. External maxillipeds with a piliferous ridge . . . . Sesarma
A'. Antennæ visible from above . . . . Plagusia

THE SPECIES OF GRAPSIDÆ.[1]

Genus Planes Leach

P. minutus (Linnæus), *MSAPD*, at surface, on floating weed

Genus Pachygrapsus Randall.

Key to Species.

A. Lateral margins strongly arcuate . . . *P. crassipes* Randall, *PD*
A'. Lateral margins converging posteriorly from the lateral tooth *P. transversus* Gibbes, *M*[2]*GD*[3]

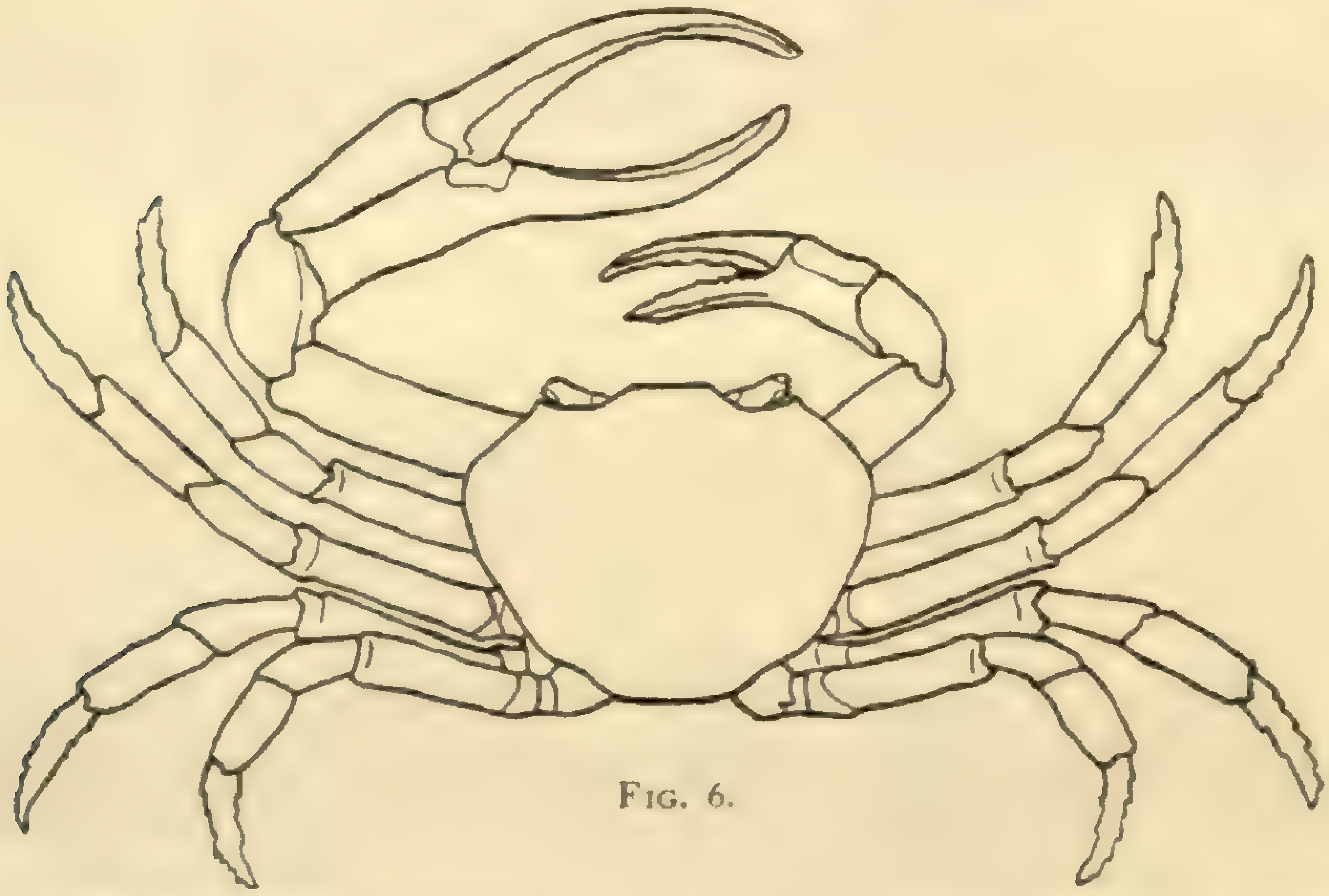

FIG. 6.

FIG. 7.

FIG. 6. — Cardisoma guanhumi. FIG. 7. — Cardisoma guanhumi, outer maxilliped.

Genus Hemigrapsus Dana.

Key to Species.

A. Front with a deep sinus at the middle *H. oregonensis* (Dana), *APD*
A'. Front arcuate, very slightly sinuous . . . *H. nudus* (Dana), *APD*

Genus Sesarma Say.

Key to Species.

A. Lateral margin toothed behind the orbital angle *S.* (*Sesarma*) *reticulatum* Say, *MSG*
A'. Lateral margin entire . . *S.* (*Holometopus*) *cinereum* (Bosc), *MSG*

Genus Plagusia Latreille . . . . *P. depressa* (Fabricius), *S*

[1] *Grapsus grapsus* (Linnæus), a tropical species, has been taken at Cape Cod from the bottom of a whaler just returned from a voyage.

[2] Occasional. [3] California (Kingsley).

Key to the Genera of the Family Pinnotheridæ.

A. Carapace convex. Eyes small.
- *B.* Ischium of outer maxillipeds rudimentary.
  - *C.* Palpus of outer maxillipeds with three joints.
    - *D.* Last joint of palpus articulated on inner margin of preceding joint.
      - *E.* Third ambulatory leg longer and stronger than the others, usually considerably so . . . Pinnixa
      - *E′.* Third ambulatory leg very little, if any, longer than the others.
        - *F.* Carapace without a longitudinal suture behind the orbits . . . . Pinnotheres

Fig. 8.

Fig. 9.

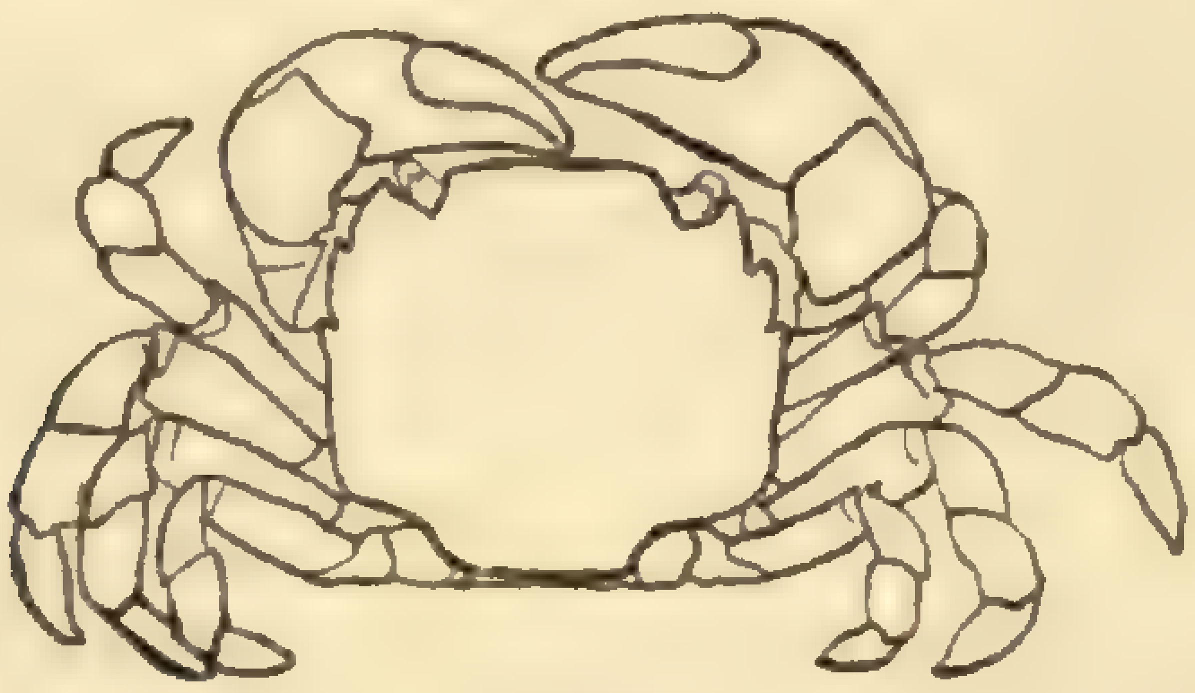

Fig. 10.

Fig. 8. — Pachygrapsus transversus, carapace.
Fig. 9. — Pachygrapsus transversus, chela.
Fig. 10. — Hemigrapsus nudus.

        - *F′.* Carapace with a longitudinal suture behind the orbits enclosing between them the median area . . . . Raphonotus
    - *D′.* Last joint of palpus articulated at end of preceding joint Echinophilus
  - *C′.* Palpus of outer maxillipeds with two joints . Cryptophrys
- *B′.* Ischium of outer maxillipeds distinctly developed . Opisthopus

A′. Carapace flat, suborbicular, truncate behind. Eyes large (for the family), each eyestalk as long as half the width of the front Zaops

The Species of Pinnotheridæ.

Genus Pinnixa White.

Key to Species.

A. Carapace firm.
- *B.* Pollex of cheliped distinctly developed.
  - *C.* Pollex much shorter than the dactylus, and usually bent downwards toward the extremity.
    - *D.* Transverse crest on the cardiac region short, not extending across the entire carapace.

E. Propodus of third ambulatory leg as broad as long, or nearly so . . *P. chætopterana* Stimpson, *M*

E′. Propodus of third ambulatory leg distinctly longer than broad.

F. Dactylus of third ambulatory leg more than half the length of the propodus, measured on the posterior margin.

G. Second pair of ambulatory legs slender, filiform, subcylindrical

P. sayana Stimpson, *M*

G′. Second pair of ambulatory legs compressed, not extremely slender nor filiform.

H. Cardiac ridge sinuous, in dorsal view

P. occidentalis Rathbun, *AP*

H′. Cardiac ridge straight, or nearly so, in dorsal view

P. californiensis Rathbun, *D*

F′. Dactylus of third ambulatory leg less than half the length of the propodus, measured on the posterior margin . *P. littoralis* Holmes, *P*

D′. Transverse crest on the cardiac region extending across the entire carapace *P. cristata* Rathbun, sp. nov.[1] *M*

Fig. 11.

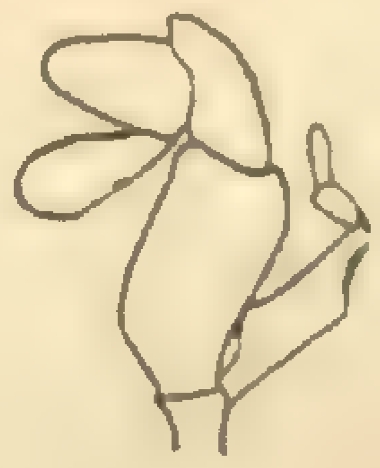

Fig. 12.

Fig. 13.

Fig. 11. — Pinnixa longipes.
Fig. 12. — Pinnixa longipes, outer maxilliped.
Fig. 13. — Pinnotheres ostreum, ♀.

C′. Pollex as long, or nearly as long, as the dactylus, and not bent downward.

D. Merus of third ambulatory leg longer than half the width of the carapace . . . *P. longipes* (Lockington), *P*

D′. Merus of third ambulatory leg shorter than half the width of the carapace.

E. Length of carapace half its width

P. cylindrica (Say), *SG*

E′. Length of carapace much less than half its width

P. tubicola Holmes, *D*

B′. Pollex wanting, represented only by the spiniform angle of the palm . . . . *P. monodactyla* (Say), American?

[1] Type, one female, Beaufort, N. C. (Union College collection).

A'. Carapace thin, membranaceous, yielding to slight pressure
. *P. faba* (Dana), *AP*

Genus Pinnotheres Latreille.

Key to Species.

A. Palm widening towards the distal end.
  B. Last joint of palpus of outer maxilliped very slender and much smaller than the preceding joint.
    C. Carapace of female very thin and membranaceous. Surface smooth and shining . . . . *P. ostreum* Say, *MS*
    C'. Carapace thicker and firmer. Surface covered with a dense pubescence . . . . *P. maculatus* Say, *MSG*

FIG. 14.—Pinnotheres maculatus, ♂.

FIG. 15.— Palicus bahamensis.

  B'. Last joint of palpus of outer maxilliped large, more than half the width of the preceding joint . . . . *P. nudus* Holmes, *D*
A'. Palm linear . . . . . . *P. byssomiæ* Say, "Our southern coast."

Genus Raphonotus Rathbun.

Key to Species.

A. Palm of cheliped widening from the proximal to the distal end
R. subquadratus (Dana), *AP*
A'. Palm of cheliped not widening from the proximal to the distal end; slightly swollen at the middle . . *R. lowei* Rathbun, sp. nov.,[1] *D*

Genus Echinophilus Rathbun, nov. *E. mellitæ* Rathbun, sp. nov.,[2] *MSG*
Genus Cryptophrys Rathbun . . . . . . *C. concharum* Rathbun, *PD*
Genus Opisthopus Rathbun . . . . *O. transversus* Rathbun, *D*
Genus Zaops Rathbun, nov. . . . . Type, *Z. depressa* (Say), *M*

[1] Types, U. S. Nat. Mus., No. 23,437, San Pedro Bay, Cal., in siphon of *Pholas pacifica*; H. N. Lowe, collector; 2 ♀.

[2] Types, U. S. Nat. Mus., No. 23,434, Pensacola, Florida, on *Mellita testudinata*; J. E. Benedict, collector.

The Species of Palicidæ.

Genus Palicus Philippi.[1]

Key to Species.

A. Crests on the second and third abdominal segments, and on the fifth sternal segment, not forming conspicuous laminiform expansions visible in a dorsal view.

B. Anterior margin of meri of second and third ambulatory legs terminating in a nearly rectangular non-projecting tooth *P. alternatus* Rathbun, *M*(*CH*)*G*

B'. Anterior margin of meri of second and third ambulatory legs terminating in a spiniform, projecting tooth.

C. Branchial regions much swollen *P. obesus* (A. Milne Edwards), *G*

C'. Branchial regions not swollen *P. faxoni* Rathbun, *M*(*CH*)

A'. Crests on the second and third abdominal segments, and on the fifth sternal segment forming conspicuous laminiform expansions visible in a dorsal view . . . . *P. sica* (A. Milne Edwards), *G*

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REVIEWS OF RECENT LITERATURE.

ANTHROPOLOGY.

Man and his Ancestor. — In an admirable little volume of 238 pages Mr. Charles Morris has presented the leading facts that go to show that man has been the outcome of a development from the lower animals. This study in evolution is written in terse and untechnical language. It is addressed to "those who are evolutionists in principle to learn on what grounds their acceptance of this phase of evolution stands, and to aid those who are at sea on the whole subject of man's origin to reach some fixed conclusion." The clear and logical interpretation of the facts — themselves established for the most part beyond controversy — certainly justifies the author's hope "that it may carry some doubters to solid land and teach some believers the fundamental elements of their faith." In a word, it is a well-written "popular treatise" that deserves to be widely read.

Two views of the origin of man exist: either he came into existence through direct creation, or by development from the lower animals. The former mode is not susceptible of proof, the latter is supported by our author with facts drawn from both biology and anthropology. Some of the principal vestiges of the ancestry of man which he carries in his own body are described. Brief mention is made of the principal discoveries of human remains and articles manufactured by man that have come down to us from prehistoric times. It is to be especially observed that all archæological evidence is cumulative, indicative of constant improvement. The four most marked distinctions between man and the lower animals are considered at some length. In the chapter upon "the conflict with nature" are set forth the prevailing beliefs regarding the time and place of man's origin, the influence environment has had upon the race, and the traces of ascent discernible in racial differences.

Notes. — In Vol. X, Nos. 4 and 5, of *L'Anthropologie* appears a valuable article upon polymasty and polythely in man. Dr. P. J. Stoyanov presents a number of new cases and reviews the results obtained by other investigators.

Mr. W. C. Mills, curator of the museum of the Ohio State Archæological and Historical Society, has prepared a report of the field work of the society for the year ending May 31, 1898, that has been published in Vol. VIII of the *Annual Publications of the Society.* The work consisted in the exploration of mounds and the addition of new data to the state archæological map. The explorations seem to have revealed little that is new, though the discovery of post molds in a mound in Knox County is worthy of note. These molds were in the form of a square twenty-seven feet on each side. In the center of the enclosure was a fire pit of yellow clay six feet in diameter. In another mound five headless skeletons were found promiscuously heaped together. This recalls the discovery made at the Turner Mounds, a number of years ago, of sixteen skulls that had been buried together.

In the *Bulletin of the American Museum of Natural History*, Vol. XIII, pp. 69–86, appears an article by Mr. A. L. Krœber upon the "Symbolism of the Arapaho Indians." It is very concisely written, and illustrated with 138 figures representing the symbols most commonly employed. These range from a straight line (Fig. 24) to a silhouette of the human figure (Fig. 124). Mr. Krœber concludes that the symbolic tendency prevails over the decorative in Arapaho art.

In the *American Anthropologist* (N. S.), Vol. II, No. 2, is published a paper by Dr. J. R. Swanton upon the "Morphology of the Chinook Verb" that should be of interest and value to students of the science of linguistics. It is an exhaustive study of the verb, prefaced by a general account of the other parts of speech in the Chinook language. This thesis was accepted at Harvard University as fulfilling the requirements for the degree of Doctor of Philosophy. F. R.

ZOÖLOGY.

A Zoögeographic Scheme for the Mid-Pacific.[1] — Some time ago (*American Naturalist*, No. 396, p. 975, December, 1899) we called attention to C. Hedley's views on the former existence of an antarctic continent; now, a recent paper has come into our hands on a subject that is intimately connected with the question of the origin of the faunas of the Central Pacific Islands, Australia, and New Zealand.

[1] Hedley, Chas. *Proc. Linn. Soc. N. S. Wales* (1899), Pt. iii, July 26.

Hedley maintains that the faunas of Australia and the Pacific Islands — generally united into the Australian region — have developed under two completely different conditions. On the one side, the western, continental conditions prevailed, Australia proper being connected with New Guinea, and New Guinea, in turn, through the Solomon Islands, New Hebrides, and New Caledonia, with New Zealand, while the Fiji Islands formed another branch of this old continental mass, being connected with the New Hebrides and Solomon Islands.

On the other side, the eastern, we have the rest of the Pacific Islands, where oceanic conditions have always prevailed, the different islands of the Gilbert, Ellice, Samoan, Tonga groups, etc., never forming a continuous continent.

This fundamental difference finds its expression in the faunas of these two parts, in so far as in the western part a "harmonic" fauna (G. Baur) exists, that is to say, a fauna that is composed of the chief groups of animal life, without considerable gaps. In the eastern part, however, such gaps are very frequent and mark the fauna at once as a "disharmonic," many important groups of animals being completely missing. In the western part a continuous migration over the whole extent of this continental mass was possible, thus favoring more even distribution of the land animals over the whole area, while in the eastern part the land fauna could only migrate by drift over the intervening parts of the ocean. which excludes at once a large number of animals.

In the *fauna of the western, or continental, part* we can distinguish three chief constituents: (1) an Australian-Autochthonian (Tate), or Eyrean (Spencer), which is restricted to Australia proper, and hardly passes beyond Queensland to the north; (2) the so-called Euronotian (Tate), or Bassian (Spencer), which is the most characteristic Australian element, and of antarctic origin; it entered Australia by the south, over Tasmania, and crossed Torres Strait into New Guinea, reaching its limit in the Solomon Islands; (3) the Torresian (Spencer) element. Its center lies in New Guinea, from whence it was connected with the Indo-Malaysian fauna. It sends off from New Guinea two branches, the one crossing Torres Strait southward and entering Queensland, the other one traversing New Britain, New Ireland, the Solomons, sending an offshoot to Fiji and another along the chain of the New Hebrides and New Caledonia, ultimately arriving at New Zealand.

In New Zealand the southern advance of the Torresian element

was met by a strong antarctic element, coming from the supposed antarctic continent. The latter may be traced up to New Guinea and is probably older than the other antarctic element that enters Australia from the south.

The *Polynesian fauna*, that of the *eastern, oceanic part*, has derived its population from two sources. The first way was from the Moluccas or the Philippine Islands through the Pelews and Carolines to the Marshalls, and thence down along the chain of archipelagoes to the Paumotu Islands; this is called the Micronesian route. The other way, the Melanesian route, started from the Fiji Islands, belonging to the Australian continental fauna, whence the respective animals crossed over by drift to the Tonga and Samoan groups. By this way Torresian, as well as antarctic elements, both being represented in the Fijis, have contributed to the Polynesian fauna, while by the first way only Indo-Malaysian (closely connected with the Torresian) elements could immigrate.

We cannot deny that this theory of the origin of the Pacific faunas has many points in favor of it; especially the explanation of the connection of the continental faunas of Australia, New Guinea, etc., to New Zealand seems very acceptable. On the other hand, Hedley's opinion of the oceanic nature of the Polynesian fauna cannot be accepted without comment. Indeed, there seems to be a sharp line, just where Hedley draws it, between Fiji on one side and the Tonga and Samoan groups on the other; but whether the "disharmonic" fauna of Polynesia is to be explained by, and is synonymous with, "oceanic origin" remains to be demonstrated. The terms "harmonic" and "disharmonic" — although they may be useful sometimes — are only of relative value; New Zealand, for instance, has decidedly a "disharmonic" fauna, but Hedley himself believes it to be of continental origin.

And, further, the theory of the oceanic origin of the Polynesian fauna is opposed to the views of some of the most prominent recent writers in *Zoögeography.* Hedley refers only to the opinion of G. Baur (as expressed in No. 31, 1897, of this journal), and, indeed, in one of the instances which he quotes (p. 412) Baur's argument derived from the distribution of Pocillopora and Trapezia is not very convincing. But there is another vigorous champion of the continental origin of the Polynesian fauna, namely, H. von Ihering, and his arguments are certainly worth discussing. Von Ihering traces the continental origin of the Polynesian fauna far back into the Mesozoic time and thus explains the "disharmonic" character of it;

the lack of certain groups of animals is apparently due to the fact that they did not exist at all at the time when there was a connection of these parts with others.

But we need further investigations on this subject, and it is not advisable to express at present a definite opinion on this topic. Hedley's paper gives one solution of the problem, and, indeed, his arguments are very important, and his theory may finally prove to be correct, at least to be the most probable. A. E. O.

The Distribution of the Opilionidæ. — Dr. J. C. C. Loman[1] has published a synopsis of the facts known about the distribution of the Opilionidæ, illustrated by four maps. It is hardly necessary to discuss the paper in detail, as the author intended simply to give the facts, without giving an explanation of them. We should like, however, to call attention to certain features of the distribution of these animals which seem to furnish additional evidence in favor of von Ihering's theories.

It will be remembered that, according to von Ihering, South America is no zoögeographical unit, but consists of two separate centers of origin; the one is situated in its southern part and was connected at a certain time with the antarctic continent; this is called "Archiplata"; the other one comprises the northern parts of the present South America, and was connected, in Mesozoic times, with West Africa. This Mesozoic continental mass has been called by von Ihering by the name of "Archhelenis."

Now, according to Loman's map (Pl. XI, Fig. 2), the distribution of the Opilionid family, Gonyleptoidæ (expressed in green dots), is in South America and the West Indies on the one side, and in West Africa on the other, and it would seem impossible to explain it in any other way than by accepting von Ihering's Archhelenis theory.

The relations of the southern parts of the present continents to the antarctic continent supposed to have existed formerly are expressed in the distribution of another family of Opilionids, the Triænonychoidæ. As Loman's map (Pl. XI, Fig. 4) indicates (by red dots), this family has been found in South Africa, Madagascar, South Australia, the Fijis, and in Chili. This distribution corresponds closely to that of other antarctic animals. A. E. O.

[1] Ueber die geographische Verbreitung der Opilioniden, *Zool. Jahrb.*, Abt. f. Syst., Bd. xiii (1900).

"The Management and Diseases of the Dog,"[1] by John Woodroffe Hill, is a most valuable addition to canine literature, containing the results of the author's many years of exceptional experience with canine diseases. We are glad to notice that in the preface Mr. Hill most emphatically expresses his views on the absurd law for muzzling dogs during a rabies panic as follows: "utterly ineffectual in stamping out rabies; partial and aggravating in its administration; injurious and cruel to the subject." His views with relation to the cure of this disease are interesting and somewhat at variance with those generally entertained at the present time, in so far as the human subject is concerned. After stating that "it was recognized centuries ago, and the alarm engendered appears to have been as great then as in the present day," he goes on to say that "rewards have been offered for the discovery of a cure, but the probability of their ever being claimed is extremely dubious, — especially so long as spurious hydrophobia and various phases of hysteria are indiscriminately mixed up and mistaken for the real malady." The measures to be taken when human beings have been bitten by a suspected dog are described, and as these are of such vital interest, it seems best to quote his directions.

"With regard to ourselves, all dog bites, as a precautionary measure, should be treated as if they were inflicted by a rabid animal, *i.e.*, by immediate suction, followed by the application of the actual cautery, nitric acid, or pure carbolic acid. When rabies is suspected the suction should be directly followed by complete excision of the wound, performed as quickly as possible; after which, without loss of time, the cautery or acid should be freely used. Compression above the wound, especially in the first instance, is also valuable. Failing the adoption of these measures, or even accompanying them, the Russian or Turkish bath should, if possible, be immediately had recourse to, and, in the absence of such measures, free and intense perspiration should be promoted by other means, such being the most efficacious treatment at present known. . . . I also advise a powerful stimulant before taking the bath, and subsequently full doses of chlorate of potash and iron."

The opening chapter is on general management, food, exercise, washing, grooming, clothing, kennel arrangement, disinfection, administration of medicine, and nursing. This last is a subject little studied in connection with animals, but it is far more difficult to nurse

[1] Fifth edition. London, Swan, Sonnenschein & Co.; New York, The Macmillan Company, 1900. 531 pp., 8vo.

a dumb creature, that cannot express clearly its needs, than a human being, and taxes one's intuition far more than can be realized by the inexperienced, who have never studied and contrasted the normal with the abnormal expressions and habits of animals. He discusses the above subjects very briefly, too briefly, in fact, as he advises some things which are opposed to the methods of many dog breeders, without sufficiently stating his reasons. For instance, on the subject of time of meals, he says: "Where only one meal is allowed [it should be given], at midday"; where only one meal is allowed it is necessarily a heavy one, and midday is, in winter, a time when a dog has generally just finished, or about to begin, his exercise, and in summer is the hottest part of the twenty-four hours. A heavy meal, while acceptable to the dog at any time, is generally given at the end of the day, when all exercise is over.

He also states: "Animal food (except an occasional bone) is not advisable in any breed of young dog,[1] until four or five months old, and it should then be *gradually, not suddenly*, introduced into the diet." He gives no reasons for the above, which is a much discussed question, and about which every breeder varies in some degree from his neighbor; but the best authorities advise the use of meat in some form or other and in variable quantities.

Mr. Hill endeavors to correct the absurd ways in which the average feminine dog owner cares for her pets, and in reading his book it becomes obvious that, if it were not for her mistaken kindness and overfeeding, the veterinary would have much fewer rare diseases and abnormal growths to study.

The diseases are classified in groups, according to the various parts of the system which they attack, and are described in a general way; then causes, symptoms, and treatment are given, and this method greatly simplifies the diagnoses, and the author's explicit and brief style throughout cannot be too highly praised.

The book is as interesting to members of the profession as to the amateur, on account of Mr. Hill's large experience with rare diseases, which he fully describes. One of the rarest which he gives is "verminous bronchitis," generally confined to animals under eight months old. An autopsy showed, in addition to pneumonia, "numerous small parasitic worms in the trachea and bronchial tubes."

Throughout the book there are liberal quotations from other authorities: from Ainslie, a case of inversion of the stomach; Hutch-

[1] Obviously meant to be "young dog of any breed."

inson, a case of intussusception of the ileum and cæcum; Weber, Leblanc, Trasbot, Youatt, Gowing and son, etc.

The chapter on Accidents and Operations covers the ground very thoroughly for the first heading, and includes, under the second, some of the more difficult operations as well as the lesser ones, such as removing of dewclaws, cropping, tailing, etc.

Mr. Hill strongly advocates the use of chloroform, saying: "On the score of humanity, however, chloroform chiefly demands our attention, and with the knowledge that we are not inflicting pain is gained strength of nerve, confidence in ourselves, and, probably, a more successful issue to our patient."

To members of his profession he writes: "We must remember that the most sacred duty of the veterinary surgeon is to prevent or alleviate pain and distress in animals."

An appendix gives a table of Medicines and their Doses, Poisons and their Antidotes, and also a Standard of Points for Judging. The standards are nearly all taken from those recommended by the various dog clubs, and consequently there are a few breeds which are not included, owing to inability to obtain a recognized standard of points in connection with them.

The photographic reproductions of famous dogs, the work of Thomas Fall, F.R.P.S., the well-known and artistic English photographer, are very handsome.

The index is full and accurate, the type clear and on good paper, and the book is of a convenient size. There are, besides those noticed in some of the quotations, many instances of defective style that might be quoted, but these are not of a kind that detract from the usefulness of the book.

There is no list of illustrations, and, considering the excellence of these, and that there are no less than eleven plates, most of them giving two figures of celebrated dogs, this is a serious omission, one that ought not to have occurred, especially in a fifth edition.

A. V. H.

Studies on Hirudinea.—A posthumous paper by the late Arnold Graf[1] discusses exhaustively the structure and activities of the excretory organs of the leech. Though not concerned primarily with classification, it contains figures of several North-American species of Glossiphonia ("Clepsine") new to science. Graf's studies of

[1] Hirudineenstudien, *Abh. der Kaiserl. Leop.-Carol. Deutschen Akademie der Naturforscher* (Halle), Bd. lxxii (1899), Nr. 2, pp. 217–404, Taf. I–XV, 26 text-figs.

the minute structure of the nephridia, made partly on fresh, partly on fixed material, form an important contribution to cytological knowledge.

He finds that leucocytes ("excretophores") play an active part in the process of excretion. Arising from the cœlomic epithelium, they become filled with excretory products in the lymph vessels, and then either migrate to the funnel apparatus of a nephridium, where they are broken up and give off their products to the canal cells of the nephridium, or else pass by amœboid movements through the walls of the lymph vessels and the muscle layers of the body to the epidermis, there to disintegrate. In either case they form the vehicle for the transportation, partial or complete, of excretory products to the surface of the body.

Pigment cells, the author finds, are a special variety of "excretophore," in which the excretory substance assumes a particular color as the cell passes to the epidermis. The formation of a definite color pattern in the leech is explained as the purely mechanical result of the migration of pigment cells along the path of least resistance toward the surface of the body. This leads to the aggregation of pigment in particular regions of the epidermis, especially between bundles of longitudinal muscles and in places where dorso-ventral muscles have their attachments. The foregoing explanation, perhaps, accounts adequately for such markings as simple longitudinal striations of a uniform color, but, in the opinion of the reviewer, fails to explain the more complicated color patterns of many leeches, in which corresponding regions of successive somites may be pigmented very unequally or in colors strikingly contrasting.

W. E. C.

The Resources of the Sea. — Professor W. C. McIntosh's volume, *The Resources of the Sea as shown in the Scientific Experiments to test the Effects of Trawling and of the Closure of Certain Areas off the Scottish Shores* (London, C. J. Clay & Sons, 8vo, 248 pp., illustrated), sheds a deal of light on a very complex problem. It treats mainly of the Scottish fisheries, those of St. Andrews Bay, the Frith of Forth, Moray Frith, and the Frith of Clyde, but summarizes on British fisheries in general. The experiments tabulated cover a period of ten years or more; they relate to the effects of the use of trawls on the abundance of fishes, on the young, on the eggs, and on the food, and also to what may be effected in the way of replenishment by closure of particular areas. The value of the book

is in keeping with the reputation of the author. His data, however, are not such as he would have chosen and are subjected, in cases, to severe criticism; he had to accept what was provided. In purpose the experiments were to direct legislation on British fisheries, but the conclusions may be applied to any marine fishery. Some fishes, cod, herring, and mackerel, for instance, are said to be inexhaustible and need no protection; others may be temporarily reduced in numbers by the fisherman. Of these latter the impoverishments are only temporary and are self-curative; nature restores and maintains the balances; extermination, as a result of man's efforts, is apparently impossible. Extended series of thorough scientific investigations are shown to be of the greatest need; for, admitting that it is not possible to exterminate, and that overfishing, through rendering the grounds unprofitable, brings its own correction, the vital question is how best to prevent depletion and to keep up the supply all the time. Aside from the species, each of the various localities must eventually be made a subject of special study, since they differ in readiness of recovery; few are so well situated for prompt renewals as the British Isles, in the broad sweep of the Gulf Stream. The author makes the statement that the California gray whale, *Rachianectes glaucus*, has been entirely destroyed by man.

"**Les Oiseaux**" is apparently the second volume in a series of handbooks on the fauna of France.[1] There is an introduction of two pages on the anatomy of the bird; the rest of the volume is made up of keys to the families, genera, and species of all birds which have been known to occur in France. There is also a brief description of each genus and species, with woodcuts of the heads of nearly every species, and many drawings of the whole bird. The status and distribution of each species are indicated.

The drawings are in the style of the early part of this century; the center of gravity is rarely over the bird's base, and if two birds of the same genus are represented, their bills differ so widely that they might almost belong to different families. The nomenclature and classification are equally antiquated; six orders include the birds which, in a British manual, are divided into seventeen. The descriptions are apparently faithful, and the small compass of the book will doubtless recommend it to field naturalists.

[1] Acloque, A. Faune de France, *Les Oiseaux*. Paris, J. B. Baillière et Fils. pp. 87–336. 621 figs.

We note several American stragglers: the robin, of course, Swainson's thrush, yellow-billed cuckoo, several waders, and the American bittern, appearing strangely as *Botaurus freti-hudsoni* (Briss.).

R. H.

Heliotropism of Cypridopsis. — The reactions of a representative of the Ostracoda, *Cypridopsis vidua*, to light have been studied by Elizabeth W. Towle.[1] This animal, when dropped into the middle of a trough which is in the course of light rays from a Welsbach burner, may move either toward the source of light or away from it. Observation of individuals shows that an animal may at one time be positive, at another negative. One cause of this variation is found to be "contact." For, however strongly negative an animal may be, it can be rendered positive by being repeatedly taken up in a pipette or by disturbance of the water.

If while a Cypridopsis is moving toward the light the burner be shifted to the opposite end of the trough, the animal will immediately turn and follow it, thus keeping up a positive reaction. Likewise, if it is moving away from the light it may be observed to change its course each time the light is moved, or, in other words, to maintain its negative reaction. The only difference is this: "In all cases the positive response was temporary, while the negative one persisted as long as the animal could be kept in motion." Contact with the sides of the trough or pipette or with obstructions therein causes a change from negative to positive; whereas the change from positive to negative occurs independently of external conditions.

Miss Towle's experiments indicate that Cypridopsis cannot be characterized as positively phototactic, and the use of an India-ink prism as a means of getting regular gradations of light intensity led her to conclude that a photopathic reaction (*i.e.*, a response to difference of intensity of adjacent rays and not to the direction of the same) has *not* been proved thus far for any animal, and probably does not exist. As a result of careful tests with the prism she decides that "the direction of movement of Cypridopsis and of Daphnia in response to light does not result from an effort on the part of the animal to reach a certain optimum intensity. It is determined (1) by the direction of the impinging rays, and (2) by the relative value of these rays as forces acting upon the organism, *i.e.*, by their relative intensities."

[1] A Study in the Heliotropism of Cypridopsis, *Amer. Journ. of Phys.*, vol. iii (1900), No. 8.

The investigation is valuable, in that it reveals the importance of "contact" as a factor in the reactions of Cypridopsis to light. The problem has been suggested, rather than analyzed, by the author, and it demands further attention. Obviously the observations fail to disprove the possibility of photopathy or the selection of an optimum intensity, although they do emphasize the importance of the rays' directive influence.

R. M. YERKES.

Notes. — *Circular No. 40*, second series of the Division of Entomology of the United States Department of Agriculture, dealing in a brief synoptical way with the mosquitoes of North America, is of unusual general interest, since it renders evident, at a glance, whether or not a prevalent mosquito belongs to the genus Anopheles, which appears to comprise the species by which human malaria is chiefly, if not exclusively, spread.

Professor E. S. Morse, in "A Bubble-Making Insect" (Appleton's *Popular Science Monthly*, May, 1900), discusses the fluid accumulations of the Cercopidæ. A "look over the literature of the subject," considered "sufficient to indicate the common belief among entomologists," cites no authority later than 1869. In writing for general readers, the latest works, rather than the earlier classics, should be quoted, and even a "superficial survey" of what has been published on the subject, if directed aright, would not have been so wholly barren as Professor Morse's paper would indicate. The froth is stated to act as a protection against enemies; certain Hymenoptera, however, provision their nests with young cercopids selected from the spits.

In a separately paged extract from the Fourth Annual Report of the Commissioners of Fisheries, Game, and Forests of the State of New York, Dr. E. P. Felt gives an account of seven insects injurious to maple trees. The species treated are the white-marked tussock moth, *Notolophus leucostigma*, forest tent caterpillar, *Clisiocampa disstria*, leopard moth, *Zeuzera pyrina*, maple sesian, *Sesia acerni*, sugar-maple borer, *Plagionotus speciosus*, maple-tree pruner, *Elaphidion villosum*, and cottony maple-tree scale, *Pulvinaria innumerabilis*. The descriptions, though brief, are accurate and adequate, and with the illustrations make the recognition of the several species easy. The title-page and cover read, "Insects injurious to forest trees, 1898." The title line, however, gives, "Insects injurious to maple trees," and at the very outset Dr. Felt states his reasons for confin-

ing his report to insects affecting shade trees. He also records the result of observations made in 1899.

Messrs. Henry Holt & Co. publish (New York, 1899) a new issue of Scudder's *Brief Guide to the Commoner Butterflies of the Northern United States and Canada.* The text shows but slight change from the original of 1893. The illustrations, borrowed from other works, are new to this issue, and give, with varying success, figures of the eighty-four species treated in the text.

"The Recognition of the Poisonous Serpents of North America," an address with a demonstration to the graduating class in the medical school, before the Johns Hopkins Medical Society, by Professor Howard A. Kelly, is printed in the *Bulletin of the Johns Hopkins Hospital*, Vol. X, No. 105. Figures of six snakes, three poisonous species and three harmless species, illustrate the paper. The disadvantages under which a physician labors when dealing with a purely zoölogical subject are clearly shown in the text.

BOTANY.

An Experimental Botany. — Teachers who believe in approaching the study of plants from the physiological point of view will welcome Dr. MacDougal's latest guide.[1] The book is intended for the use of beginners who have not the facilities of a laboratory. Only a hand magnifier and such apparatus as may be extemporized readily with the aid of household articles are required in the observations and experiments to which the student's attention is directed. It will be a surprise to many teachers to find how fully the more important general principles of plant physiology may be illustrated by these simple experiments, while the young people who perform the experiments cannot fail to be delighted with what they will witness, and be led to valuable general ideas of plant life. The book abounds in fresh and inspiring suggestions.

It must be said, however, that users of the book are assumed to have acquired sufficient knowledge of systematic botany and facility

[1] MacDougal, Daniel Trembly, Ph.D., Director of the Laboratories, New York Botanical Garden. *The Nature and Work of Plants: an Introduction to the Study of Botany.* New York, The Macmillan Company, 1900. Cloth, 12 mo. xvii + 218 pp.

in the determination of species to enable them to make ready use of such works as *Gray's Manual* and *Britton and Brown's Flora.* No help in learning how to analyze is here afforded, although the student is expected to determine during the course a considerable number of plants. To call the book "An Introduction to the Study of Botany" would seem to be, therefore, somewhat misleading.

The prominence given to physiological matters leaves opportunity for but scant consideration of the form and structure of parts — scarcely enough, it would seem, for a full understanding of the text, except on the supposition that the student is receiving or has received supplementary instruction. Some of the morphological statements call for correction. Thus we find fruit defined as "the seed and all parts of the ovary adhering to it" (p. 155) — a strangely inadequate definition, which is contradicted by the statement (on p. 176) that the "fruit of the apple is composed of portions derived from all the organs of the flower." It seems strange, also, to find such an unqualified statement of this old notion of the apple's morphology, in view of the simpler modern theory now generally adopted.

As regards physiological matters the treatment leaves but little to be desired. One statement, however, would seem to require modification, namely, where it is said (on p. 45) that the spongy layer enveloping the roots of air plants will "gather water from the air when it is humid and damp." The careful experiments to test this matter by R. G. Leavitt, detailed in *Rhodora* for February and March, 1900, make it appear highly improbable that aërial roots ever have this power of absorbing watery vapor which has been frequently ascribed to them on meager evidence.

In spite of its defects, which are not likely to prove of much consequence where there is a good teacher, the book is sure to rank well among recent helps to the study of plants as living things.

F. L. S.

Prantl's Lehrbuch.[1] — The new edition of Prantl's excellent text-book of botany follows essentially the same lines as the last edition, the chief modifications consisting of a general expansion which amounts to about fifty pages. Numerous changes and additions in the matter of illustration have resulted in an increase of twenty-seven cuts. Several of these new cuts illustrate the micro-

[1] Prantl. *Lehrbuch der Botanik*, herausgegeben und neugearbeitet von Dr. Ferdinand Pax. Elfte, verbesserte und vermehrte Auflage. Leipzig, Engelmann, 1900. 456 pp., 414 figs.

scopic structure of drugs. Another feature of pharmacognostical interest is an appendix of about ten pages, giving a brief synopsis of the officinal plant drugs of the German Pharmacopœia.

The subjects usually treated in books of this class are here presented in a clear, concise text, which is very effectively supplemented by the excellent woodcuts.

It is hardly necessary to point out the good qualities of a book that has proved its usefulness by long service. It is enough to say that it is distinctly improved in the new edition and will remain one of the most serviceable of the shorter botanical text-books.

R. H. T.

"Lessons in Botany."[1]—The increased attention to botany in high-school courses during the last few years has resulted in a rich crop of elementary texts designed to meet the new conditions. In the preparation of many of these texts it has been assumed that a full year's time could be given to this subject. Very many schools, however, are not yet able to devote more than a half year to the study of plants, and abridged editions are consequently beginning to appear.

Atkinson's *Lessons*, a volume of three hundred and sixty-five pages, is such a work. The opening chapter on germination, winter buds and shoots, is succeeded by the study of protoplasm and its properties, as observed in root hairs, Spirogyra, and Mucor. About eighty-six pages are given to a study of the physiology of flowering plants. Part II, dealing with the morphology and life history of representative types, begins with Spirogyra and Vaucheria, following the usual sequence up through the ascending series of forms. When the study of the angiosperms is taken up a chapter on seeds and seedlings is introduced. Here the types discussed differ from those in the opening chapter.

Part II is concluded by Studies on Plant Families. Twenty or more lessons are devoted to the morphology and ecology of about as many plants. Part III, including about sixty pages, is given up to ecology. So far as the ecological adaptations of the individual plant under ordinary conditions is concerned, this phase of botany seems admirably adapted for use in the high school; but when the study of plant communities introduces zones of tension and other landscape features the value of the subject in a half year's high-school course is doubtful. Descriptions of swamps near Ithaca can hardly take

[1] Atkinson, George Francis. New York, Henry Holt & Co., 1900. 365 pp., 277 figs.

the place of work afield, for which the students whom this book is designed to aid are likely to lack time and opportunity. With this exception the *Lessons* seem to the writer well adapted to the ends they are intended to meet.

The author has an interesting style of presentation. The abundant illustrations, of which many are original, are very good.

R. H. T.

Notes. — Part I of *The Queensland Flora*, a handbook by F. Manson Bailey, Colonial Botanist, recently issued, contains the orders Ranunculaceæ to Anacardiaceæ and is illustrated by twelve plates representing some of the rarer species.

Volume II of the *Meddelanden* of the Botanical Institute of the Stockholm University contains thirteen articles covering morphological and physiological studies on flowering plants and morphological and taxonomic studies on certain cryptogams, chiefly fresh-water algæ.

Mr. Holm's *Studies in the Cyperaceæ, XII*, deals with *Carex filifolia* Nuttall, from which are segregated *C. elynoides* (*C. filifolia* var. *miser*) and *C. oreocharis* (*C. filifolia* var. *valida*).

Messrs. J. U. and C. G. Lloyd, of Cincinnati, whose practical interest in botany has been shown already in many ways, have begun the publication of a "reproduction series" of Bulletins, the first of which, fresh from the press, is a facsimile of Barton's *Collections for an Essay towards a Materia Medica of the United States*, accompanied by a biography and portrait of the author.

PALEOBOTANY.

Cretaceous Plants.[1] — Professor Lester F. Ward, with the collaboration of W. P. Jenney, W. M. Fontaine, and F. H. Knowlton, presents an elaborate discussion of the cretaceous flora of the Black Hills in relation to the geological age of the various strata in which the plants occur. Eighty-six species are enumerated, of which nineteen belong to the Pteridophyta, forty-eight are gymnosperms, and the

[1] Ward, Lester F. The Cretaceous Formation of the Black Hills as indicated by the Fossil Plants, *U. S. Geol. Surv.*, 1899, pp. 525–712, Pls. LVII–CLXXII.

remaining seventeen belong to the angiosperms. Special interest centers in the very large number of cycads, — twenty-five species in all, — which were obtained in a remarkably fine state of preservation. Of these, twenty species belong to the Cycadoidea, the majority of the specimens (126) belonging to the Marsh collection of the Yale Museum.

A critical comparison of the flora of the various horizons with corresponding types and formations elsewhere in America and Europe leads the author to the unqualified conclusion that "the sandstones of the Black Hills belong to the Dakota group proper, or No. 1 of Meek and Hayden, while the recent contention that the cycad and other plant-bearing beds form a part of the Jurassic may be regarded as definitely overthrown."

D. P. P.

Fossil Cycads.[1] — Professor Lester F. Ward continues his studies of fossil cycads by a notable contribution to the Washington Academy of Sciences on twenty new species from the Jurassic of Wyoming. This material first came to notice in 1898, through Professor O. C. Marsh, and since then a large amount of additional material in the form of well-preserved trunks has been obtained. It is a noteworthy fact that these fossils not only represent new species, but they also represent an entirely new genus, for which Professor Ward proposes to use the name of Cycadella. The chief points of contrast with the cycads of the Black Hills are to be found in the relatively small, bulbous, subspheroidal, or subconical trunks, which are encased in a layer, 5–15 mm. thick, of dense tissue consisting of a chaffy ramentum, which arises from the leaf bases and becomes matted so as to form a thick outer covering.

D. P. P.

Fossil Cycads.[2] — The very remarkable collection of cycads from the Black Hills and other localities, brought together by the late Professor Marsh and now to be found in Yale Museum, has led Mr. G. R. Wieland to supplement the admirable studies of Professor Ward by a more detailed macroscopic and microscopic examination of these plants in all their parts. His preliminary studies give important details respecting the character of the inflorescence, the structure of

[1] Ward, Lester F. Description of a New Genus and Twenty New Species of Fossil Cycadean Trunks from the Jurassic of Wyoming, *Proc. Wash. Acad. Sci.*, 1900, vol. i, pp. 253–300, Pls. XIV–XXI.

[2] Wieland, G. R. A Study of Some American Fossil Cycads, *Amer. Jour. Sci.*, 1899, vol. vii, pp. 219, 305, 384.

the foliage, and the nature of the fructification in *Cycadoidea ingens* and *C. wielandi.* The superb character of this collection, both in extent and perfection of preservation, as also in the very unusual fact that the inflorescence is preserved in great perfection of detail, leads us to hope for the most important results bearing upon our knowledge of the earlier history of these very interesting plants, and botanists will look forward with keen interest to the completion of these important studies. D. P. P.

The Yale Collection of Cycads.[1] — Mr. G. R. Wieland contributes a short account of the very remarkable collection of cycads now in the Yale Museum, which will prove of interest to paleobotanists as a concise account of the origin, number, and general character of these valuable specimens. In the Yale collection there are many beautiful cycadean fronds from the Triassic sandstones of the New Haven region, and more than six hundred silicified trunks chiefly from the Upper Jurassic of the Black Hills. In addition to these, the fact of three other American collections in the United States National Museum, the University of Wyoming at Laramie, and at the Woman's College, Baltimore, is noted. Figures and general descriptions of thirteen species are given. D. P. P.

Fossils of the Norwegian North Polar Expedition.[2] — An interesting result of the Nansen Expedition comes to us in the form of a paper by A. G. Nathorst on the "Fossil Plants from Franz Josef Land." Twenty-nine species in all are described, and one fungus parasite on a coniferous leaf. The plant-bearing stratum lies between two basalt beds, and a comparative study shows that it is in all probability Jurassic, the flora corresponding most nearly with that from the Jurassic of Siberia and Spitzbergen. The unfortunately fragmentary condition of the material leaves much in doubt as to the specific identity of several species, as well as of the exact horizon to which they belong. The following summary of species may be found of interest: Cladophlebis 1, Sphenopteris 4, Pterophyllum 1, Podozamites 1, Ginkgo 3, Czekanowskia 1, Phœnicopsis 1, Fieldenia 1, Taxites 1, Abietites 1, Pityanthus 1. D. P. P.

[1] Wieland, G. R. *The Yale Sci. Monthly*, 1900, vol. vi, pp. 1–11, 2 plates.

[2] Nathorst, A. G. The Norwegian North Polar Expedition, 1893–1896. III, Fossil Plants from Franz Josef Land, pp. 3–26, Pls. I, II. Longmans, Green & Co.

Rothamsted Experiments.[1] — The present account by Lawes and Gilbert continues the results derived from forty-four years of continuous experimentation upon the same land. The general results so far reached show very characteristic differences in the composition of the ashes of different crops according to the amount of nitrogen they assimilated; and upon this is based the conclusion that "independently of any specially physiological function of the bases, such as that of potash with the formation of carbohydrates, their office was prominently also that of *carriers of nitric acid*, and that when the nitrogen had been assimilated, the base was left as a residue in combination with organic acid, which, according to the character of the plant, was represented more or less completely by carbonic acid in the ash."

D. P. P.

Plants in Calcareous Tufa.[2] — Mr. J. M. Hulth presents an interesting study of the plants found in the calcareous tufa of western Gothland in the region of Falköping and Sköfde, and discusses the vegetation of seven different horizons with respect to their relation to the flora of the Arctic, Boreal, and Atlantic periods. The vegetation found corresponds with existing types.

D. P. P.

Fossil Flora of the Cascade Range.[3] — Studies of the fossil plants associated with the lavas of the Cascade Range, prosecuted during the last five years, have been completed by Professor F. H. Knowlton. Twenty-eight forms in all are described, and they include such types as have hitherto been found in the Miocene only, from which the author concludes unhesitatingly that the beds are of Miocene age.

D. P. P.

Flora of the Coal Layers of Lâ Ternera.[4] — Solms-Laubach presents a short account of the plants derived from the Coal Formation

[1] Lawes, Sir J. B., and Gilbert, Sir J. H. Agricultural, Botanical, and Chemical Results of Experiments on the Mixed Herbage of Permanent Grass Land; III, Chemical Results, *Phil. Trans. R. Soc.*, vol. cxcii (1900), pp. 139–210.

[2] Hulth, J. M. Ueber einige Kalktuffe aus Westergötland, *Bull. Geol. Inst. of Upsala*, 1898, vol. iv, pp. 5–40, Pl. I.

[3] Knowlton, F. H. Report on the Fossil Plants associated with the Lavas of the Cascade Range, *U. S. Geol. Surv.*, vol. xx, III, 1898–99, pp. 37–52, Pls. I–VI.

[4] Solms-Laubach, H. von Grafen zu. *Neue Jahrb. f. Mineral.*, etc., vol. xii, 1899, pp. 581–609, Pls. XIII, XIV.

at La Ternera, Chili. Ten species of gymnosperms and ferns are enumerated, and they serve to indicate that the beds belong to the Lower Lias.

D. P. P.

PALEONTOLOGY.

Notes on Fossil Fishes. — In the *Bulletin of the Geological Society of America* Mr. C. R. Eastman has an account of the fossil fishes of Jurassic formations in the Black Hills of South Dakota. The paper is supplementary to one by N. H. Darton on the same subject. The Jura-Trias of America has yielded very few fishes, and the scanty remains noted by Mr. Darton and Mr. Eastman represent about all that is known of the fish fauna of the period as represented in American deposits. In the present paper are given descriptions and photographic representations of *Pholidophorus americanus* and *Amiopsis* (?) *dartoni*. The relations of Pholidophorus are discussed in some detail, it being regarded as the type of a distinct family, Pholidophoridæ.

In the *Memoirs of the New York Academy of Sciences* Dr. Bashford Dean discusses the relationships of the alleged fossil lamprey of the Devonian, *Palæospondylus gunni*. In Dr. Dean's view this species is not a lamprey, nor related to the cyclostomes. It is probably a larval form, possibly of the Arthrodira genus Coccosteus. The Arthrodira, according to Dr. Dean, "cannot be strictly included among the fishes," and with their relatives (Anarthrodira), all also extinct, should be placed in a distinct class, Arthrognathi, by themselves.

In the *Journal of Geology* Mr. C. R. Eastman describes and figures the teeth of a number of Devonian fishes, the following being described as new: *Cladodus monroei*, from the Hamilton formation at Milwaukee; *Dipterus uddeni* and *D. calvini*, from the Middle Devonian, New Buffalo, Iowa; *D. costatus* and *D. mordax*, from North Liberty, Iowa.

D. S. J.

A slab of limestone with numerous specimens of *Uintacrinus socialis* Grinnell, recently placed on exhibition in the Yale University Museum, is noticed and figured in the April number of the *American Journal of Science*. A similar and somewhat larger slab in the Museum of Comparative Zoölogy is figured in the Annual Report of the Museum for 1898–99.

NEWS.

The Academy of Natural Science of Philadelphia receives by the will of the late Charles E. Smith one-sixth of his estate, which is valued at about $500,000. His collections and botanical library also go to the academy.

Dr. James M. Safford, the state geologist of Tennessee and professor in Vanderbilt University, retires at the end of the present year.

The University of the State of Missouri is to send an Entomological Expedition into southern Mexico this summer. It will be in charge of Professor J. M. Stedman, head of the entomological department, and will have for its object the making of a biological, largely entomological, survey of the region from Vera Cruz, on the Gulf, which is in perpetual tropics, to the top of the volcano Popocatepetl, which is far above the perpetual snow line, and down to Acapulco on the Pacific. This will give all the temperature variations from perpetual tropics to perpetual snow, and will allow of the study of life zones under conditions not to be found elsewhere in North America. The collection will become the property of the university, which is to furnish half the expenses, the other half to be borne by Professor Stedman.

Appointments: Dr. Charles W. Greene, professor of physiology in the University of Missouri. — Mr. S. Harbert Hamilton, assistant in the museum of geology and archæology at Princeton University. — Dr. Franz Kossmat, docent in geology in the University of Vienna. — Dr. Paul Ehrenreich, docent in ethnology in the University of Berlin. — Stuart Weller, instructor in paleontology in the University of Chicago. — Alfred L. Kroeber, curator of anthropology in the California Academy of Sciences. — Dr. A. L. Treadwell, professor of zoölogy in Vassar College. — R. H. Yapp, assistant curator of the herbarium in the University of Cambridge.

Deaths. — Dr. George Viner Ellis, for many years professor of anatomy in University College, London. — Dr. Bernhart Nöldeke, assistant in zoölogy in the University of Strassburg.— Lieutenant-General A. H. Lane-Fox Pitt-Rivers, the well-known English ethnologist, in London, May 4, aged 73. — George Highfield Morton, an English geologist, aged 73.

NOTE.

Organs of Vision. — Dr. Theodor Beer, whose valuable studies on the sensory organs of both vertebrates and invertebrates are well known, is engaged in writing a comprehensive work on the *Comparative Anatomy and Physiology of the Organs of Vision*, and to make this as complete as possible he is anxious to acquire separates of all articles — for which, if desired, he will send his own writings in exchange — dealing in any way whatever with the anatomy, embryology, zoölogy, pathology, or literature of the organ of sight in animals or the eye of man, or with reactions to light. Dr. Beer is particularly desirous that none of the widely scattered writings of Americans should escape his attention and, therefore, especially invites the coöperation of all Americans who can aid him.

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PUBLICATIONS RECEIVED.

(Regular exchanges are not included.)

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American Museum Journal. Vol. i, No. 1. April. — *Bulletin Geographical Society of Philadelphia.* Vol. ii, No. 5. March. — *Bulletin of the Johns Hopkins Hospital.* Vol. xi, Nos. 109, 110. April and May. — *Bulletin of the Natural History Society of New Brunswick.* Vol. iv, No. 18, Pt. iii. 1899. — *The Forester.* Vol. vi, No. 5. May. — *The Insect World.* Vol. iv, No. 4. April. — *Proceedings of the Rochester Academy of Science.* Vol. iii, Pt. ii, pp. 151–230. March. — *Revista Chilena de Historia Natural.* Ano iv, Nos. 2–3. February and March. — *Science Gossip.* New Series. Vol. vi, No. 72. May. — *Johns Hopkins Hospital Reports*, vol. vii, Nos. 5–7, contains Bloodgood, J. C., Operation on 459 Cases of Hernia, etc., pp. 224–567, plates. — Wisconsin Geological and Natural-History Survey, *Bulletin Nos. 5–6*, contains Grant, U. S., Preliminary Report on the Copper-Bearing Rocks of Douglas County, Wis., 55 pp., and Salisbury, R. D., and Atwood, W. W., The Geography of the Region about Devil's Lake and the Dalles of the Wisconsin, 151 pp., plates.

(*No. 402 was mailed June 21.*)

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DEVOTED TO THE NATURAL SCIENCES
IN THEIR WIDEST SENSE

CONTENTS

PAGE

I. On the Nesting Habits of the Brook Lamprey (Lampetra wilderi)
ROBERT T. YOUNG and LEON J. COLE 617

II. On Variation of the Rostrum in Palæmonetes vulgaris Herbst
DR. GEORG DUNCKER 621

III. Some Additional Data on the Position of the Sacrum in Necturus
Professor FRANK SMITH 635

IV. A Strange Abnormality in the Circulatory System of the Common Rabbit (Lepus sylvaticus) . . . . Professor J. R. SLONAKER 639

V. The Origin of the Middle Ocellus of the Adult Insect . CHUJIRO KOCHI 641

VI. Synopses of North-American Invertebrates. XII. The Trematodes. Part I. The Heterocotylea or Monogenetic Forms
Professor H. S. PRATT 645

VII. Reviews of Recent Literature: *Zoölogy*, Garman's Deep-Sea Fishes, Jenkins on Labroid Fishes of Hawaii, Greene on the Caudal Heart of the Hag-fish, Jordan and Snyder on Fishes of Mexico, Notes on Recent Fish Literature, Compensatory Movements of the Eyes in Fishes, Development of Lepidosiren, Multiplication of Nuclei in Transversely Striped Muscle Fibres of Vertebrates, Are the Solpugids Poisonous? New Jersey Insects, Mating Instinct in Moths, A New Text-Book on Echinoderms, Notes — 663
Botany, Alternation of Generations in Algæ, Micro-Organisms and Fermentation, Notes — 678
Palæontology, Zittel's Text-Book 681

VIII. News 683

IX. Publications Received 685

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THE

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ON THE NESTING HABITS OF THE BROOK LAMPREY (LAMPETRA WILDERI).

ROBERT T. YOUNG AND LEON J. COLE.

THE following notes on the nesting habits of the brook lamprey are not intended to cover completely this subject, but merely to amplify in a few details the observations of Gage[1] and Dean and Sumner.[2]

While at Ann Arbor, Mich., in the spring of 1899, we had the opportunity of observing several hundred brook lampreys nest building and spawning. They were in two small streams, about four miles west of Ann Arbor. The smaller was a tributary of the larger, and the latter emptied into the Huron River, a few miles from where my observations were made. From the mouth of this stream to Lake Erie the distance was about forty miles. We shall designate the smaller stream as A and the larger as B. Both streams flowed through meadow land. At points they were bordered by alders and willows.

[1] Gage, Simon Henry. Lake and Brook Lampreys of New York, *The Wilder Quarter Century Book*, 1893.

[2] Dean, Bashford, and Sumner, Francis B. Notes on the Spawning Habits of the Brook Lamprey (Petromyzon wilderi), *Trans. New York Acad. of Sci.*, vol. xvi. Dec. 9, 1897.

The stream bottom was mainly gravelly, but in many places sandy. The average width of stream B was ten feet, and of stream A three and one-half feet. Both had a moderately swift current.

Our observations were rather brief, covering only a portion of five days, from April 15 to April 20. Previous to April 15 there had been a succession of several warm days. On the 15th there was a decided fall of temperature. On the 17th another warm spell set in. On the 20th the temperature of the water at 4 P.M. was 63° F.

Gage is of the opinion that the males precede the females at spawning time and commence nest building before the arrival of the latter. This opinion is supported by the results obtained from a weir in the inlet of Cayuga Lake, N.Y., in the spring of 1898, which are recorded by Surface,[1] and also by our own observations. Following is a record of the number and sex of the fish taken by us during the period of observation.

APRIL.	TIME OF OBSERVATION.	♂	♀	♀ SPAWNED.
15	3–5 P.M.	1	—	—
17	3–5 P.M.	8 or 10[2]	—	—
18	4–6.30 P.M.	44	11[3]	—
19	5.30 A.M. to 6.30 P.M.	98	18	9
20	3–4.30 P.M.	52	14	4

The activity of the lampreys and their manner of nest building are shown by the following results, which are the average of sixteen nests observed.

TIME OF OBSERVATION.	NO. OF STONES MOVED.			
	Up Stream.	Down Stream.	Lateral.	No. of Fish.
4½ minutes	4	2	1	2–3

[1] Surface, H. A., M.S. The Lampreys of Central New York, *Bulletin for National Fishery Congress, United States Fish Commission* (1897), pp. 145–371.

[2] Stream A only. [3] Probably all gravid.

We do not think the lampreys have any definite method in the construction of their nests. When they seize a stone they usually endeavor to carry it straight ahead, without other instinct apparently than to remove it from the nest, no matter in what direction they may be heading. Often, however, they allow themselves to be carried down stream by the current, together with the stones which they have seized. A lamprey has been seen to carry a stone up stream a short distance and then allow itself to drift back again with it. In a few cases they have been observed to carry stones into the nest from without. They cling very persistently to whatever object they may have attached themselves, on one occasion a lamprey permitting itself to be lifted from the water attached to the boot of one of the writers. Contrary to the observation of Gage and Dean and Sumner, we have noted two lampreys move a stone conjointly. The largest stone moved (only an inch, however) by a single lamprey weighed thirty-three grams. In moving stones the lamprey arches its back and employs powerful brush-like movements of the tail against the stream bed, as in spawning. As noted by Dean and Sumner, one lamprey will frequently seize another and pull it away from its place of attachment. It is very interesting to watch them do this. One seizes another by the head and shakes it as a dog would a rat. In so doing they are usually carried out of the nest by the current, holding to each other for a short distance, when they separate and return to the nest.

The size of nests and depth of stream over them is expressed by the following data, which are the average for twenty-six nests.

Diameter ‖ to Current.	Diameter ⊥ to Current.	Depth of Stream.
7½ inches	7⅛ inches	15 inches[1]

There is considerable variation both in the form and situation of the nests. The longer diameter may be either parallel or perpendicular to the current. They may be situated in any

[1] Average for twenty-five nests.

depth of water from six to twenty-four inches, near the bank or in the middle of the stream, under an overhanging bank or log, or in open water. The number of fish in a nest varies from one to thirty or forty (usually from three to twenty-five).

On the morning of the 19th the number of lampreys observed was much smaller than on the preceding afternoon. While there were no fish present in stream A on that morning, there had been quite a number there on the afternoon of the 18th. About noon of the 19th they became numerous again. We were on the spawning grounds till sunset on the 18th, and from sunrise on the 19th, and no marked migration of fish was observed at any time. For about two hours, however, before noon of the 19th we were exploring another stream, and there may have been a return of the fish to their spawning grounds at that time. Why the fish were less numerous on the morning of the 19th, or what became of them during the preceding night, it is difficult to conjecture. We have to thank Professor Jacob E. Reighard of Ann Arbor for numerous valuable suggestions and assistance in conducting our observations.

Through the kindness of the editor of the *American Naturalist* the following note from Professor Gage has been forwarded to the writers, and they take pleasure in appending it herewith :

As pointed out by Jordan and others who have made a special study of the American brook lamprey (*L. wilderi*), none have ever been found parasitic upon fishes, and none have ever been found in the waters of brooks except during the spawning season. To explain the apparent anomalies in the life history of the brook lamprey, Gage (*Proc. Amer. Assoc. Adv. Sci.* [1898], p. 372, and [1899] p. 256) carried on observations in laboratory aquaria for four years and made field observations upon the same subject during the entire year. It was found that the brook lamprey : (1) never goes to the larger waters of the lake, but remains constantly in the brooks ; (2) it attains its full size during the larval state ; (3) it is never parasitic, although a special œsophagus is developed as in parasitic forms (sea and lake lamprey), and the lingual and buccal teeth are fairly well developed ; (4) during the transformation period the animal remains under the sand like a larva (from September till April), during which time the eggs and zoösperms ripen ; (5) when the spawning season arrives (April–May) they emerge from the sand, build their nests, spawn, and disappear.

ON VARIATION OF THE ROSTRUM IN PALÆMONETES VULGARIS HERBST.

GEORG DUNCKER.

Last summer, at the Cold Spring Harbor Biological Laboratory of the Brooklyn Institute, I investigated the number of rostral spines in 1050 shrimps, in order to test the relation between the average value of a varying character and its variability.

As is well known, Verschaeffelt (**'94**) first assumed the ratio between the probable deviation of a character and its median to be an absolute measure of its variability. Such ratios as probable deviation or median average deviation, or root of average square deviation to mean have been called "coefficients of variation" and have been frequently used, not only in merely arithmetical processes, but also in dealing with morphological questions; for instance, in applying them, Brewster (**'97**) and Field (**'98**) meant to show the variability of systematically important characters to be higher than that of other ones. Both Davenport (see Brewster [**'97**]) and Pearson (**'97**) believe the higher variability of homologous characters to be connected with the higher average value. Dr. Davenport, to whom I am much indebted for his kind interest and for numerous suggestions during my stay at Cold Spring Harbor, assumes the relation between the index of variability of a character and its average value to be similar to that between the errors of measurement and the length of a course measured by the chain used in surveying.

Now, in my opinion (**'99**), there is no relation whatever between the average and the variability of a character. While the average value is determined by such conditions as equally affect all the individuals of a form unit, external conditions (environment, climate, food, quality of soil or water), as well as constitutional conditions (specific nature, sex, stage

of development), the variability depends upon numerous minute positively and negatively acting causes, a part of which only affects, in each case, the simple individuals of form unit in different combinations. Then the relative frequency of the individual variants in a form unit corresponds to the possibility of these combinations. Therefore, the causes of variation are to be thought of as essentially different from the conditions determining the average value of a character in the total form unit. On the other hand, I assume a relation between the morphological and physiological peculiarity of the different characters and the causes of their individual variation, so that the single characters are only able to react on a part of the sum total of the latter ; therefore, in allied species homologous characters ought to show similar indices of variability, but not necessarily equal average values.

In 1892 Weldon investigated the numbers of dorsal and ventral spines of the rostrum in 915 individuals of *Palæmonetes varians* Leach from Saltram Park, near Plymouth, England. When I learned from Dr. Davenport that these numbers are markedly higher in the closely allied, if not identical, species, *Palæmonetes vulgaris* Herbst, at Cold Spring Harbor, I took up the investigation of 1050 individuals of the latter form in order to try, in at least one case, which opinion held true. If there existed any relation between average and variability, the latter ought to be sensibly higher in *P. vulgaris* than in *P. varians*. If I was right, the variability of the number of rostral spines, in spite of the higher average in *P. vulgaris*, ought to be about the same in both species.

I shall follow Weldon and deal with the males and females together, for among the 1050 individuals caught in the seine, only 92 were males. The males are much smaller than the females. The empirical results obtained from *P. vulgaris* are given in a table of combinations, those of *P. varians* (for comparison) in series of variations.

Explanation of letters used in the tables :

f, empirical, *y*, theoretical frequencies ; *n*, total number of individuals investigated ; Δ, error between empirical and theoretical series of variation in percentages of *n* ; *A*, arithmetic

TABLE I. — COMBINATIONS IN PALÆMONETES VULGARIS

Dorsal spines		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	*Palæmonetes vulgaris*	*Palæmonetes varians*
Ventral spines	0				1	2	1	1	2								7	3
	1						1	2	2	1							5	276
	2							1	15	31	8	1					57	630
	3							4	79	513	287	36					919	6
	4								1	21	28	7	1		1		59	$n = 915$
	5												1	2			3	
Palæmonetes vulgaris	*f.*				1	2	2	8	99	566	323	44	2	2	1		$n = 1050$	
	y.			.1	.2	.7	2.7	14.5	106.2	548.2	330.0	40.8	5.3	1.0	.3	.1	$\Delta = 1.63\%$	$\Delta\sqrt{n} = .5297$
Palæmonetes varians	*f.*		2	18	123	372	349	50	1	$n = 915$								
	y.	.1	1.7	18.3	122.2	374.6	345.9	51.7	.5	$\Delta = .31\%$	$\Delta\sqrt{n} = .0949$							

TABLE II. — CONSTANTS OF VARIATION.

	P. VULGARIS.		P. VARIANS.	
	DORSAL SPINES.	VENTRAL SPINES.	DORSAL SPINES.	VENTRAL SPINES.
A	8.2819	2.9781	4.3137	1.6984
ϵ	.8145	.4477	.8627	.4799
M	8.3079	3.1391	4.4634	
G	8.2395		4.2158	
δ	.8379		.9137	
a	1.4666		4.5457	
m	3.1260		42.2128	
τ	.2357		114.5962	
yo	623.86		.212733–25	
V	8.3632		10.6333	
$c.v.$	9.83%	15.03%	20.00%	28.26%

mean ; ϵ, index of variability = root of average square deviation from arithmetic mean ; M, mode = abscissa of maximum ordinate (ym) of the theoretical curve ; G, geometric mean ; $\delta = \sqrt{A^2 - G^2}$ (see Duncker ['**99**], p. 38) ; a, standard dimension of abscissa ; m, τ, exponents ; yo, ordinate of origin of theoretical curve ; θ, abscissa to yo ; $c.v.$, coefficient of variation = 100 ϵ : A.

The theoretical curves, the polygons of which are represented in Pl. I, *C*, *D*, by dotted lines, belong to type IV, Pearson ('**95**) ; they are of the form,

$$y = yo\,(\cos\theta)^{2m} e^{-tg\,\theta},$$

where $tg\,\theta = \frac{x}{a}$ x means deviation from θ, and have been calculated by the method *A* (moments not modified) of Davenport ('**99**).

From this table we get the following results. The dorsal spines are much more numerous in both species than the ventral ones, and their variability is 1.8 times higher than that of the latter. The mean values of the homologous characters are about twice as large in *P. vulgaris* as in *P. varians*; nevertheless, the indices of variability are nearly equal in both species, in *P. vulgaris* even a little lower than

in *P. varians.* Judging from the coefficient of variation, however, we should find the numbers of ventral spines more variable than those of the dorsal ones, and the homologous characters only half as variable in *P. vulgaris* as in *P. varians.* Thus the coefficients of variation give quite different results from those obtained from the indices of variability, and only the latter ones, as Pl. I shows, correspond to the real conditions of variation in the four characters compared. *Therefore, in our examples, the indices of variability alone, not the coefficients of variation, are morphologically significant, and the former are similar in homologous characters, but independent of their mean values.*

The numbers of dorsal spines vary regularly, according to type IV of Pearson ('95) in both species with negative asymmetry of the variation curves, that is, the modes are higher than the means. It is remarkable that the ordinate of origin of the curve of *P. varians* lies at 10.63 of the abscissa, even higher than the mean and the ordinate of origin of *P. vulgaris.* Since both species, wherever they occur, are represented by immense numbers of individuals, their range of variation in the character considered probably extends much farther than will be expected from the empirical results of the investigations made by Weldon and myself. The variation curve in *P. vulgaris* is more symmetrical than that of *P. varians,* according to its small *t*-value. In both cases the agreement between the empirical series of variations and the theoretical one is thoroughly satisfying, the area of error between their two polygons remaining far behind its allowed upper limit,

$$\Delta\% = \frac{100}{\sqrt{n}}.$$

The numbers of ventral spines vary irregularly, which may partly be due to their small variability. In *P. varians* we find a curve of type I (asymmetrical, limited to both sides), where, however, the value $5\beta_2 - 6\beta_1 - 9$ is negative,[1] and where, accordingly, the index of asymmetry of this curve has a different sign from its third moment about the mean. In

[1] For explanation of these symbols, see Davenport ('99), or Duncker ('99).

P. vulgaris we get a curve of type IV, showing considerable asymmetry of its slope, probably in consequence of the abnormal frequency of the zero variant, while the empirical polygon of variation apparently corresponds to a nearly symmetrical curve. Of course there is no agreement between these curves and the empirical series of variation.

The correlation between the numbers of dorsal and ventral spines in *P. vulgaris* is positive, as is the rule in antimerically arranged homologous characters; its coefficient $r = .3878 \pm .0177$.

Besides variation in the number of spines there are some more individual differences in the shape of the rostrum of *P. vulgaris,* which will be seen from Figs. 2–27. The total rostrum may be compared with a knife, the blade of which is serrated on both edges, its handle bearing spines only on the back. In the spaces separating the spines there are feathered hairs in a single series; from the smooth ventral surface two rows of hairs extend from each side downward, like the rafters in a roof. In the males (Figs. 2–5) the rostrum is generally more slender and its handle longer than in the females (Figs. 6–27). While in *P. varians* Weldon found the apex of the rostrum bifid in more than half (52.8%) of all the individuals investigated, in our *P. vulgaris* it always was single-pointed.

With increasing numbers the spines stand together more closely and extend more forward to the apex of the rostrum (*cf.* Figs. 17 and 19 with Figs. 6 and 7); in case of very high numbers (extreme variation) they are sometimes irregularly arranged and of different sizes (Figs. 14–16, 18). Spines are rarely bifid (Fig. 13, third ventral), reduced (Fig. 20, between second and third dorsal; Fig. 21, behind first ventral) or entirely absent in a part of the otherwise normal rostrum (Fig. 22, between second and third dorsal). Very frequently, however, especially among the smaller numbers of spines, one meets with curious malformations (Figs. 5, 23–27), apparently due to regeneration, the rostrum, on account of its exposed situation, suffering easily from traumatic injuries. It would be interesting to learn if in the course of several moltings the

rostrum regenerates typically, that is, according to its individual variation of shape and of number of spines.

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EXPLANATION OF PLATE I.

PL. I. Polygons of variation of numbers of spines; empirical polygons are given by continuous, theoretical ones by dotted lines.

A, ventral spines of *P. varians*.

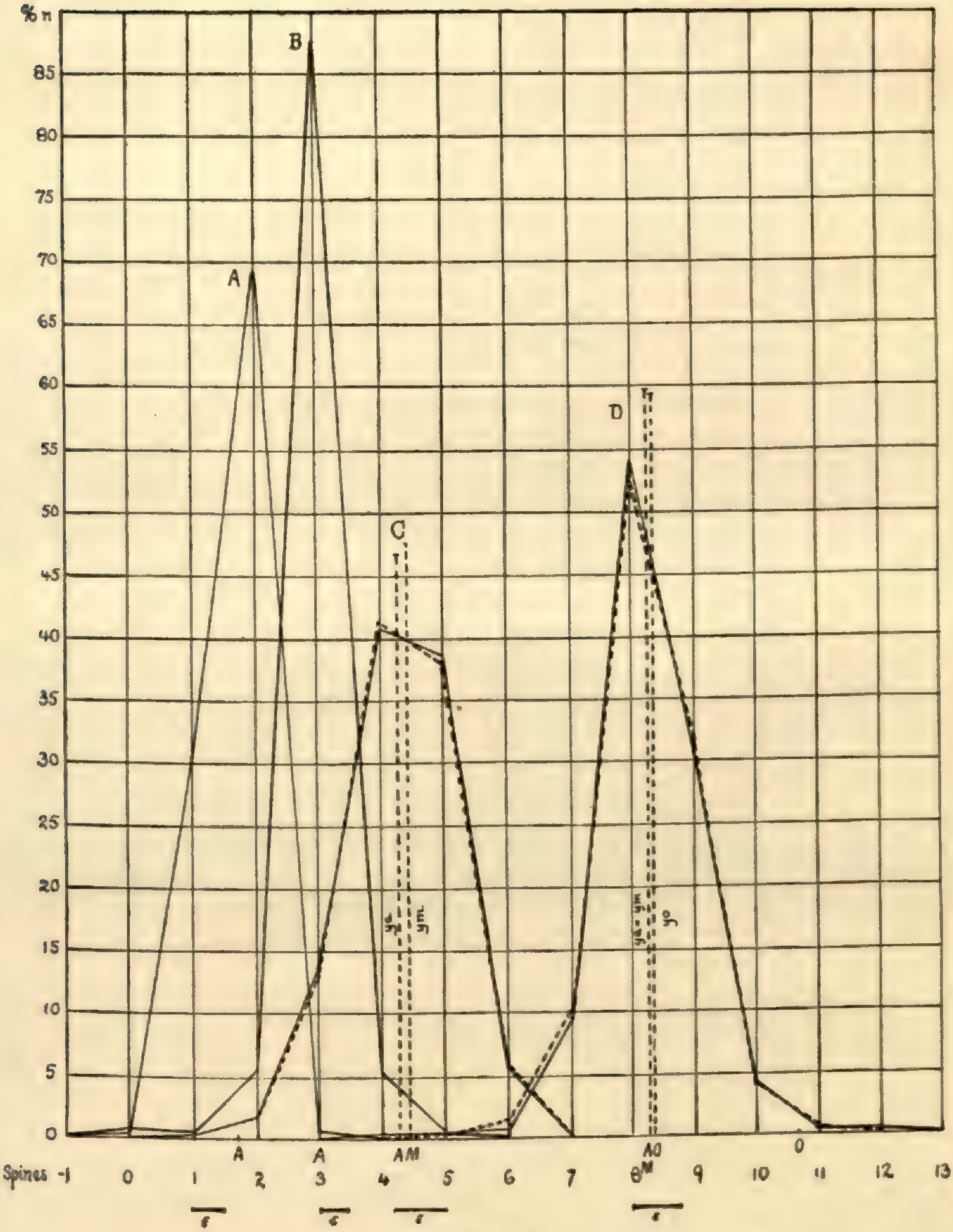
B, ventral spines of *P. vulgaris*.

C, dorsal spines of *P. varians*.

D, dorsal spines of *P. vulgaris*.

ϵ, index of variability of polygon above.

ya, *ym*, *yo*, ordinates of theoretical curves to *A*, *M*, *O*, of abscissa; compare explanation of letters used in table, p. 624.



% n
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80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
A
B
C
D
Spines -1
0
1
2
3
4
5
6
7
8
9
10
11
12
13

PLATE I.

EXPLANATION OF PLATE II.

Camera drawings of rostra.

(Leitz, Oc. 1 ; Zeiss Obj. A,* II.)

FIGS. 2–5. Male rostra.

FIG. 2. Normal, 6 dorsal, 3 ventral spines.

FIG. 3. Normal, 9d. 3v.

FIG. 4. Irregular, 8d. 1v.

FIG. 5. Malformed, 5d. 0v.

FIGS. 6–22. Normal female rostra.

FIG. 6. Normal, 5d. 2v.

FIG. 7. Normal, 6d. 3v.

FIG. 8. Normal, 6d. 3v. (sixth dorsal broken).

FIG. 9. Normal, 7d. 3v.

{FIG. 10. Small irregularities in
{FIG. 11. position of spines, 7d. 3v.

FIG. 12. Normal, 7d. 4v.

FIG. 13. Third ventral bifid, 8d. 3v.

FIG. 14. 10d. 3v. irregular position of spines.

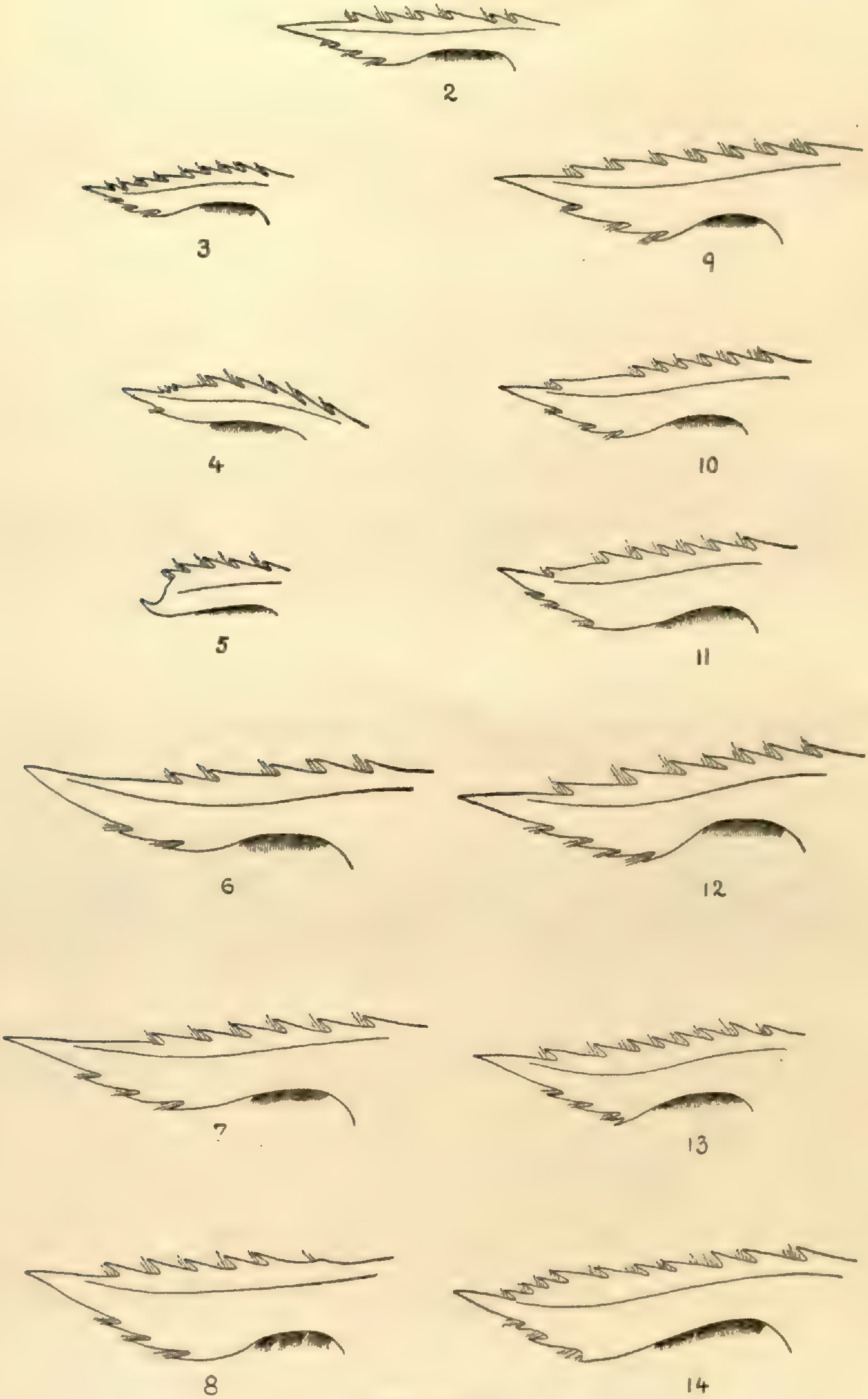
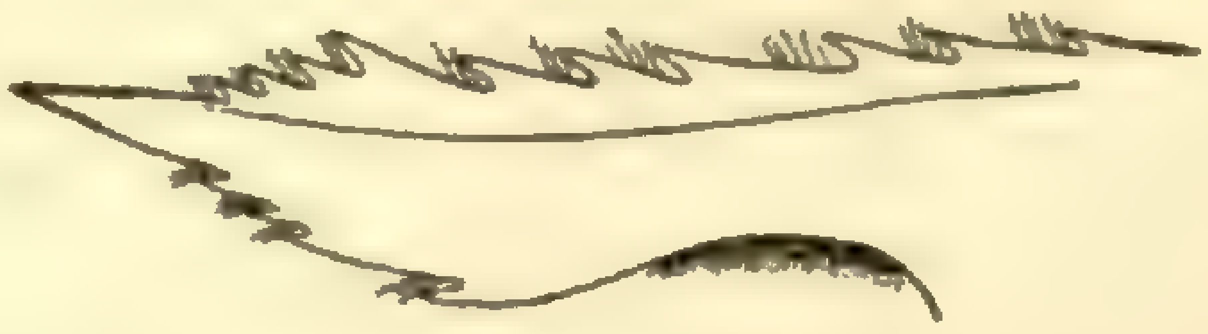


PLATE II.

EXPLANATION OF PLATE II (*Continued*).

FIG. 15. 10d. 4v. } irregular position of spines.
FIG. 16. 12d. 5v. }
FIG. 17. Normal, 12d. 5v.
FIG. 18. Irregular position of spines, 12d. 6v. (not in table ; found later).
FIG. 19. Normal, 13d. 4v.
FIG. 20. Some spines reduced, 6d. 3v.
FIG. 21. Some spines reduced, 7d, 1v.
FIG. 22. Some spines missing, 5d. 3v. (abnormally small).
FIGS. 23–27. Malformed female rostra.
FIG. 23. 8d. 3v.
FIG. 24. 8d. 3v.
FIG. 25. 7d. 3v.
FIG. 26. 6d. o(?)v.
FIG. 27. 4d. ov.



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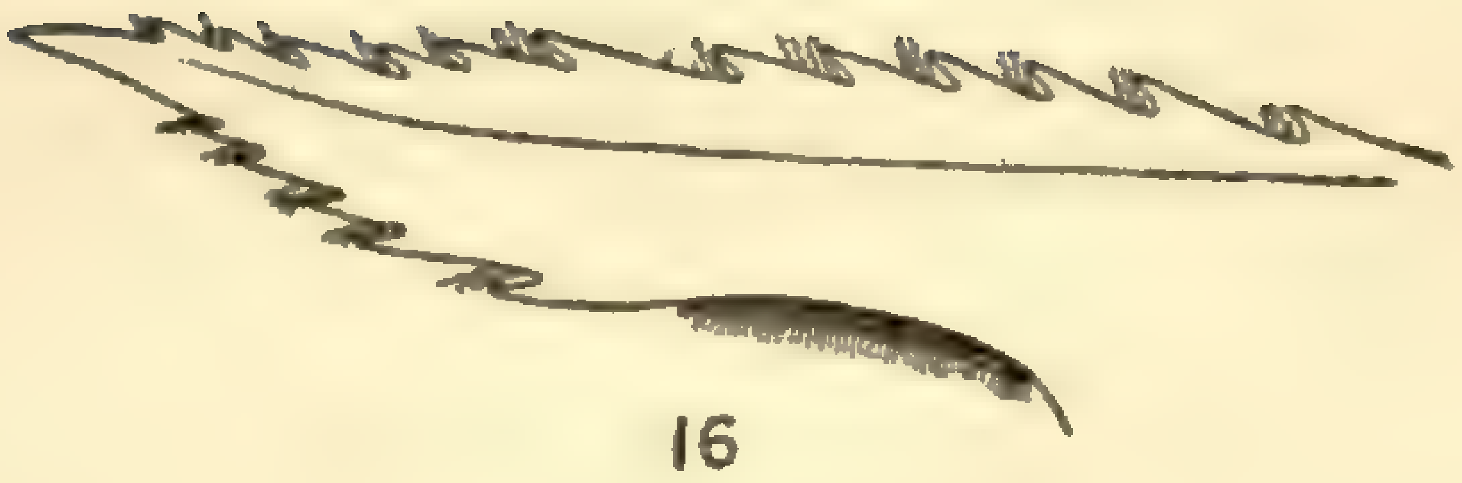

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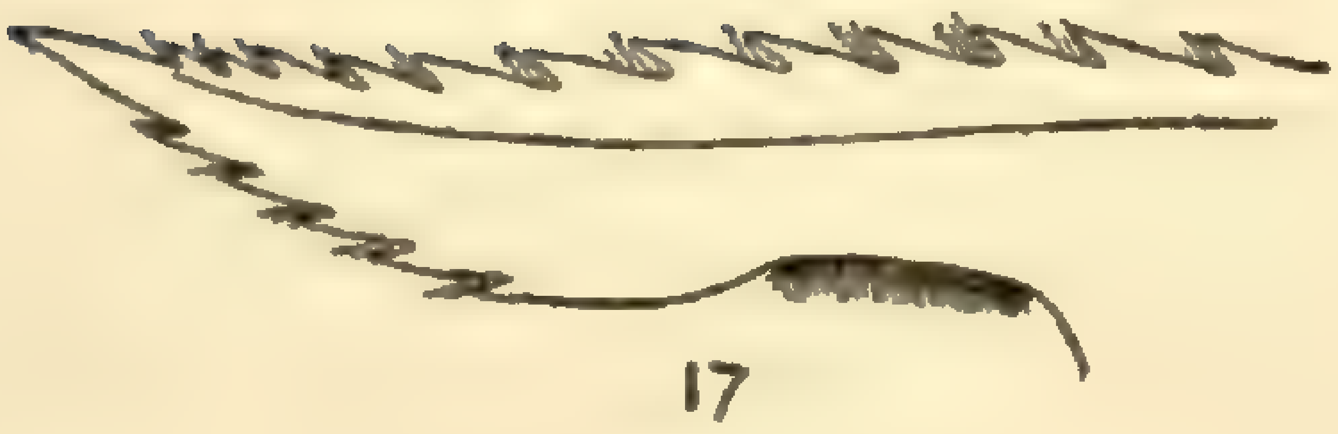

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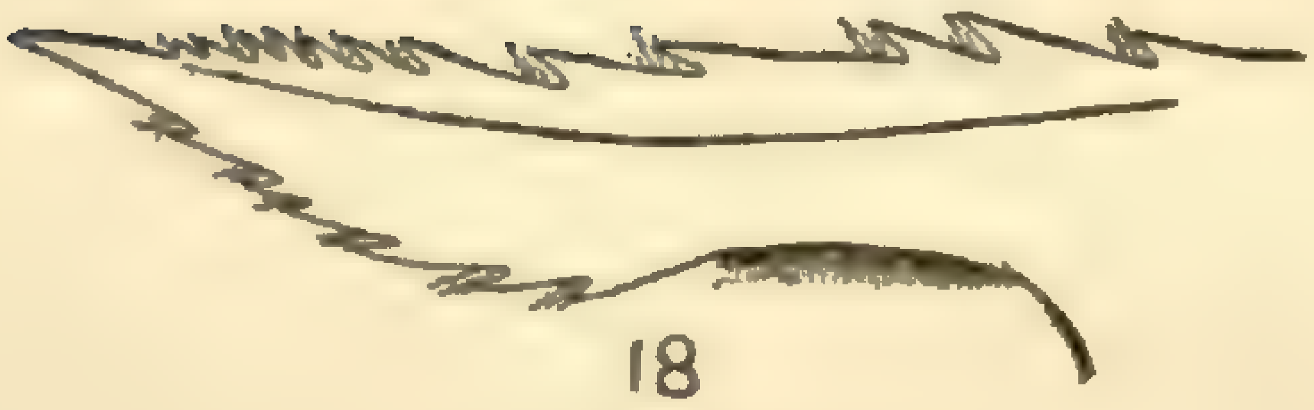

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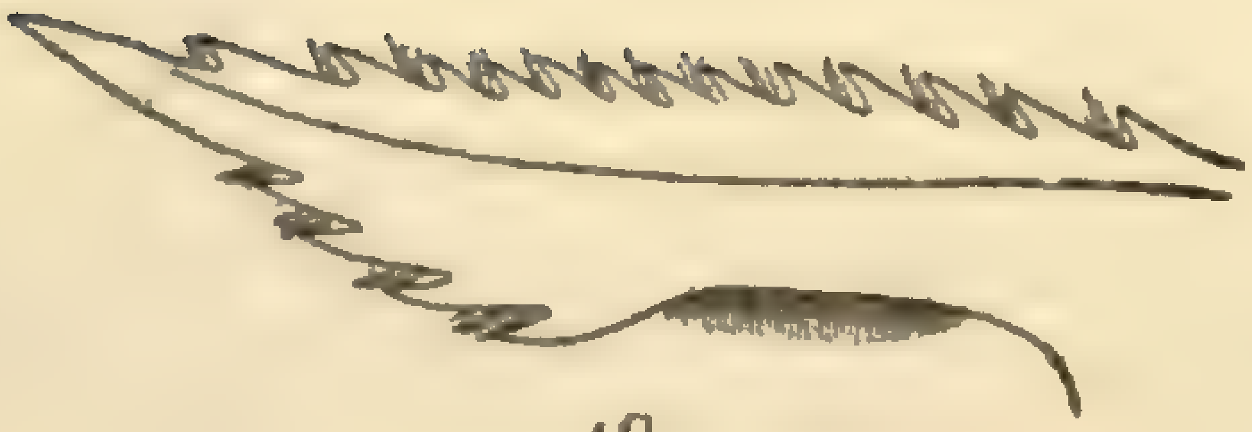

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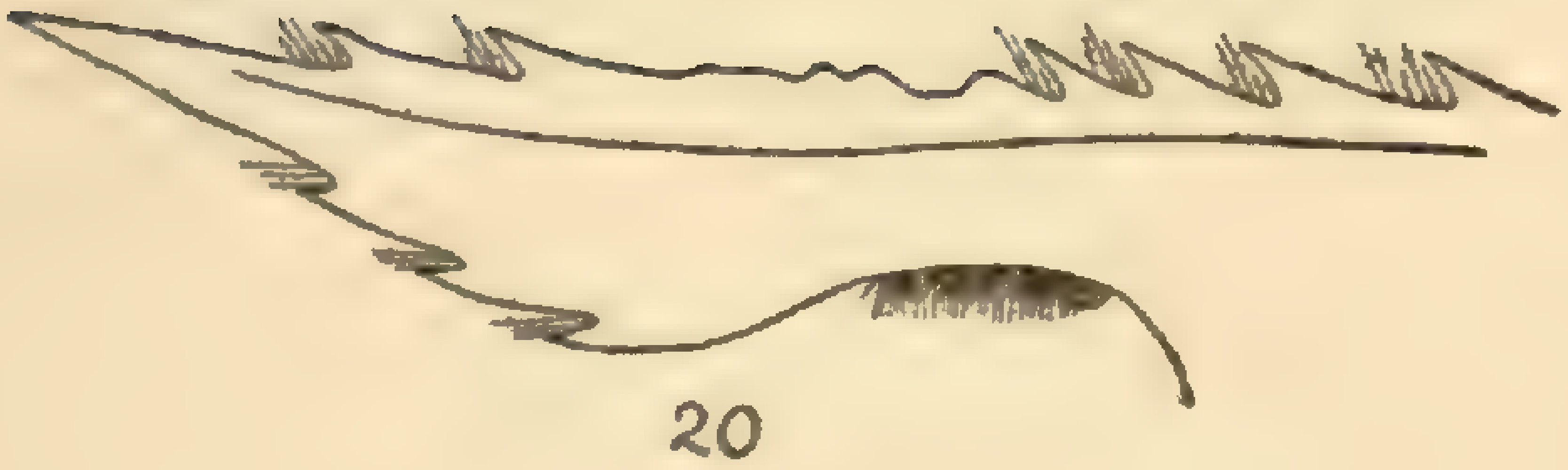

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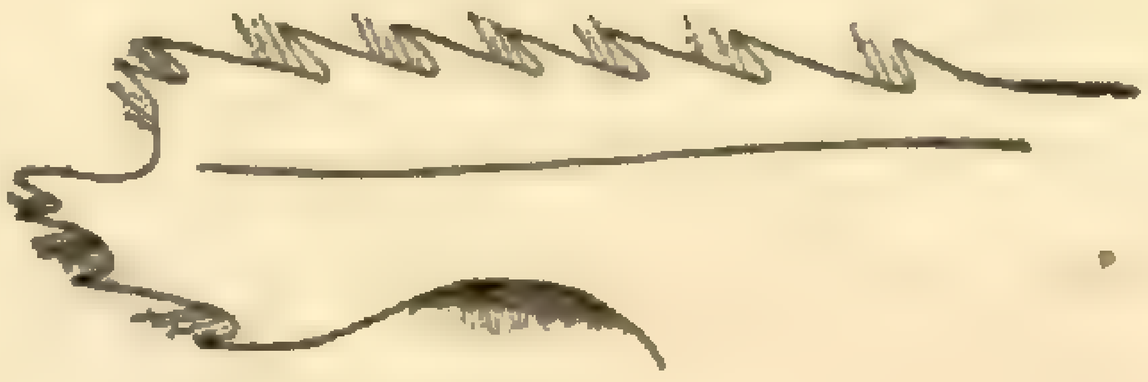

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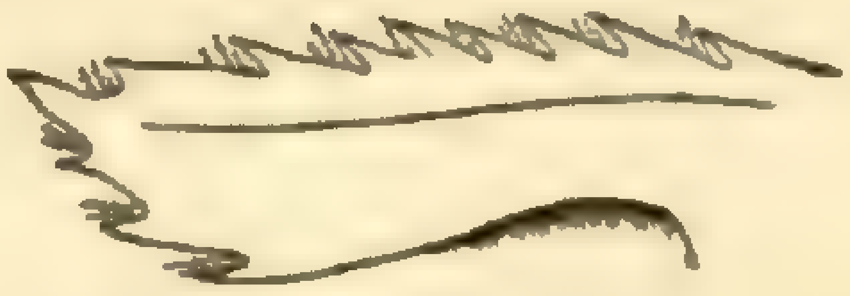

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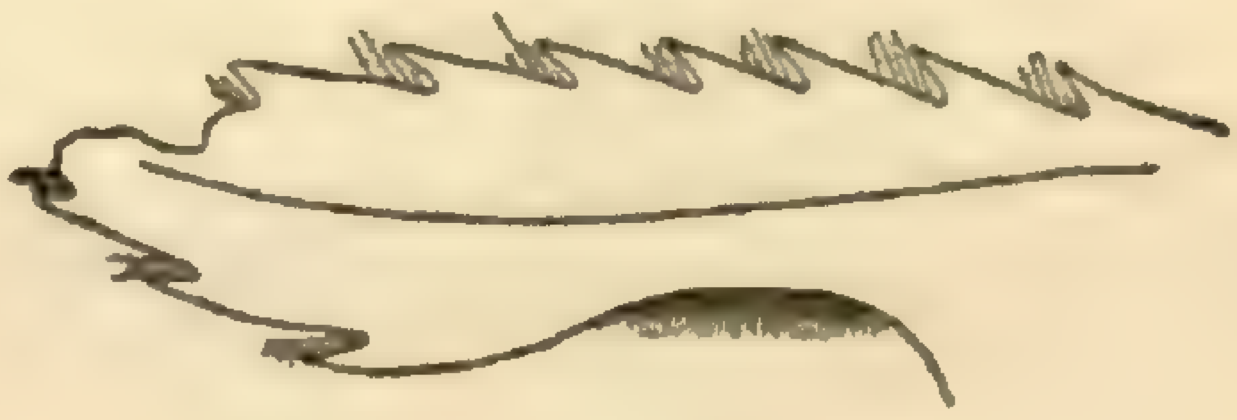

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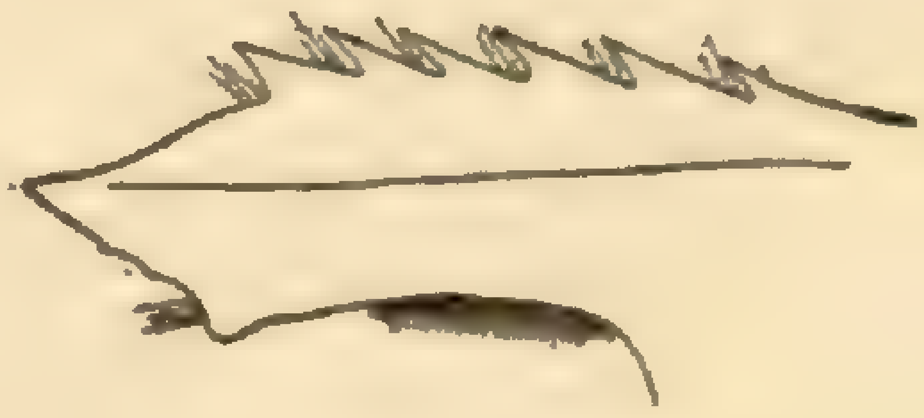

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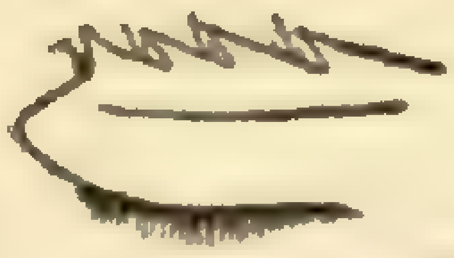

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PLATE II.

SOME ADDITIONAL DATA ON THE POSITION OF THE SACRUM IN NECTURUS.

FRANK SMITH.

THREE papers[1] which deal incidentally with the position of the sacrum in *Necturus maculosus* Raf. have appeared within recent years, in each of which are mentioned several instances of variation from the typical symmetrical sacrum on the nineteenth vertebra, and they record observations on 158 specimens. The use of *N. maculosus* as an object of study in some of the zoölogical classes of the University of Illinois has made it easy to accumulate additional information on the position of the sacrum in this species, and since data of this kind have a recognized value, and since certain variations from the normal condition have been found which have not been previously reported, it seems worth while to publish a brief account of the relations of the sacrum in the 114 specimens which have been examined in our laboratories. The material was all obtained from Lake Erie, near Sandusky, Ohio, during the years 1897–99.

Table I presents in a convenient form the data from the above-mentioned specimens, but as thirty-two of them were not examined for the position of the first hæmal arch they are tabulated in a separate column.

For convenience in a comparison of the various observations mentioned, Table II has been prepared. It relates to 241 specimens — the 158 specimens previously recorded, the eighty-two specimens listed in Table I, in which the position of the first hæmal arch is known, and one other specimen listed in that

[1] Parker, G. H. Variations in the Vertebral Column of Necturus, *Anat. Anzeiger*, Bd. xi, pp. 711–717.

Bumpus, H. C. A Contribution to the Study of Variation (Skeletal Variations of Necturus maculatus Raf.), *Journ. of Morph.*, vol. xii, pp. 455–484, 3 pls.

Waite, F. C. Variations in the Brachial and Lumbro-Sacral Plexi of Necturus maculosus Raf., *Bull. Mus. Comp. Zoöl.*, vol. xxxi, No. 4, pp. 71–92, 2 pls.

table, in which the position of the first hæmal arch is unknown, but which has three sacral ribs.

TABLE I.[1]

VERTEBRA WHICH CARRIES SACRUM.	NUMBER OF SPECIMENS.	FIRST HÆMAL ARCH ON			
		Vertebra 22.	*Vertebra 23.*	*Vertebra 24.*	*Vertebra ?*
XIX	81	30	33		18
XX	16		4	2	10
XXI	1			1	
R. XVIII . . . L. XIX	2	2			
R. XIX . . . . . L. XVIII . . .	1	1			
R. XIX . . . . . L. XX	3		3		
R. XX . . . . . L. XIX	6		2	1	3
R. XVIII . . . L. XVIII, XIX	1	1			
R. XIX . . . . . L. XIX, XX . .	2		1		1
R. XIX, XX . . L. XIX	1		1		
Total	114	34 = 41 % of 82	44 = 54 % of 82	4 = 5 % of 82	32

Some of the data listed in the above tables deserve further mention. One of the most striking points is the occurrence of as many as five individuals having three sacral ribs. Waite mentions one such instance, which I think is the only one previously recorded for *N. maculosus*, while among the 114 individuals examined by us there are four such cases. One of these has, as an additional peculiarity, two sacral ribs on the eighteenth vertebra, and is the first one recorded in which that vertebra is invaded on both sides. The figure shown on p. 638 represents the eighteenth, nineteenth, and twentieth vertebræ

[1] R. and L. are used as abbreviations for right and left.

TABLE II.[1]

Character and Position of Sacrum.	No. of Specimens Recorded by			241 Specimens.
	Parker.	Bumpus.	Waite.	
Symmetrical.				
XIX — 22	4	10	10	54
XIX — 23	15	52	10	110
XIX — 24		2		2
XX — 22		1		1
XX — 23	6	24	7	41
XX — 24		3		5
XXI — 24				1
Asymmetrical.				
R. XVIII, L. XIX — 22		1	2	5
R. XIX, L. XVIII — 22				1
R. XIX, L. XX — 23			1	4
R. XX, L. XIX — 23	1	7		10
R. XX, L. XIX — 24				1
R. XXI, L. XX — 24	1			1
R. XVIII, L. XVIII, XIX — 22				1
R. XIX, XX, L. XIX — 23			1[2]	2
R. XIX, L. XIX, XX — 23				2[3]

with the sacral ribs and ilia from the dorsal side. The dotted lines indicate the outlines of the cartilage and other tissue forming the articulations between the ilia and sacral ribs, as

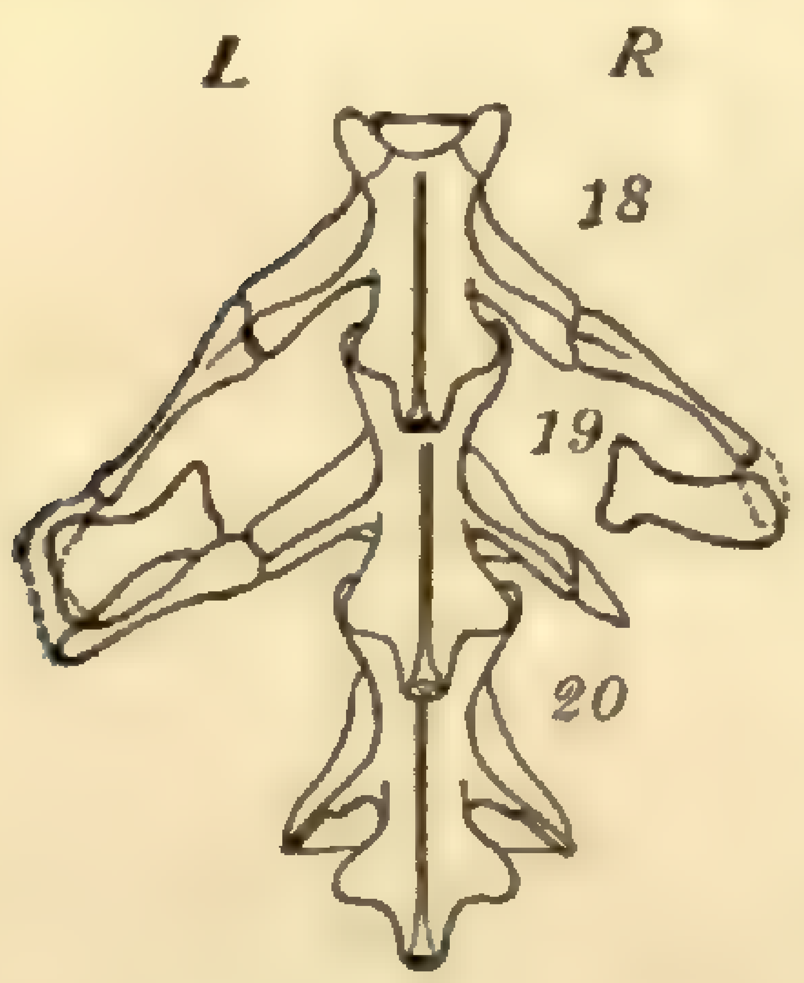
[1] The Arabic numerals are used to designate the vertebra bearing the first hæmal arch.

[2] The position of the first hæmal arch of this specimen is not recorded.

[3] The position of the first hæmal arch in one of these specimens is unknown.

seen in the dried skeleton. The two sacral ribs on the left side are about equal in size and share alike in the support of the ilium.

The other four specimens having three sacral ribs, listed in Table II, each have paired sacral ribs on the nineteenth vertebra, while the unpaired sacral rib is borne on the right side of the twentieth vertebra in two of them, and on the left side in the other two. Twenty-five specimens are listed which have an asymmetrical sacrum with but two sacral ribs, and in nine of these the sacral rib of the right side is further cephalad, while in the remaining sixteen it is the left sacral rib which is in advance. It seems curious that in the first ten specimens which were reported as having this condition of the sacrum, nine should have had the left side in advance, while in the next fifteen over half of them should have the right side in advance; and again it is singular that, of six specimens in which the eighteenth vertebra is invaded, five of them should have the right side in advance, while in the remaining nineteen cases fifteen should have the left side in advance. It is evident that data from a much larger number of specimens must be obtained before trustworthy generalization can be made.



One individual found during the past winter and listed above has a symmetrical sacrum on the twenty-first vertebra, a condition not previously recorded, I believe; and in one specimen described by Parker this vertebra was invaded on the right side; but these two specimens are the only ones, so far as I know, in which the twenty-first vertebra is invaded by the sacrum.

I am under obligations to Mr. Ralph G. Mills, a student at the University, for making the drawing for the figure, and also for the examination of a considerable number of the specimens studied.

University of Illinois.

A STRANGE ABNORMALITY IN THE CIRCULATORY SYSTEM OF THE COMMON RABBIT (LEPUS SYLVATICUS).

JAMES ROLLIN SLONAKER.

In the March number of the *Naturalist* an article appeared "On the Frequency of Abnormalities in Connection with the Postcaval Vein and its Tributaries in the Domestic Cat (Felis domestica)." Such variations are quite familiar to those who have charge of laboratory work in vertebrate anatomy. The abnormalities are, however, by no means confined to the region indicated in the above article. They are common to other parts of the circulatory system.

Though the author does not discuss the probable causes of these abnormalities, he suggests that they may be due in part to "domestication, in breeding, disease, drugs, and shock."

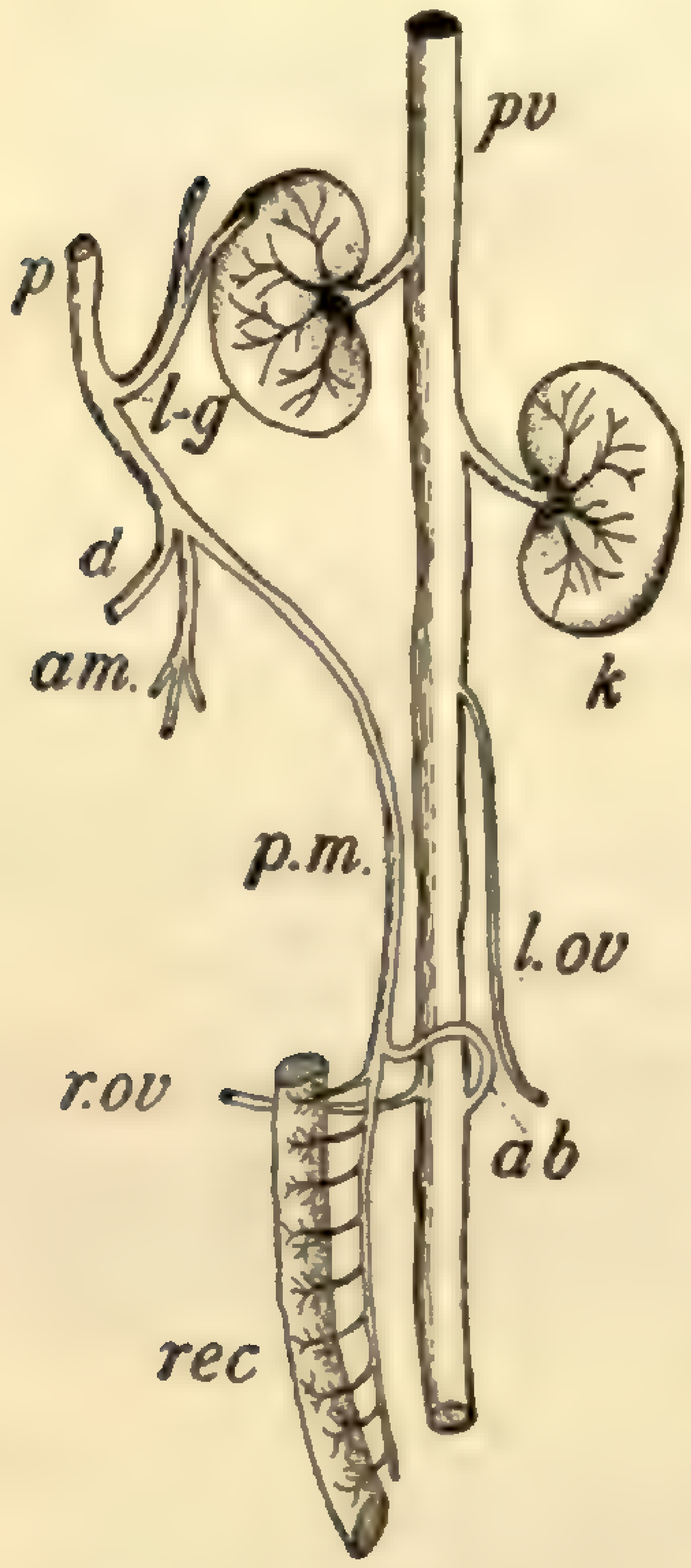
I have found that abnormalities in the circulatory system are not confined to the domesticated cat, but are also of frequent occurrence in the common gray rabbit.

The most noticeable variation that I have found, and the only one which I shall describe, was found in the venous system of the rabbit. I have found it but once and, as I have seen no mention of such an occurrence in the literature pertaining to this subject, I will describe it.

In injecting the posterior vena cava from the heart I was amazed by the rapid filling of the portal veins. This continued until they were as well injected as the other veins of the body. The injecting fluid used was a starch mass which was too coarse to pass from the vena cava through the capillaries of the liver into the portal vein. The inference was that there was a vein of sufficient size forming a direct connection between the portal vein and the posterior vena cava.

Careful dissection showed this supposition to be true. A small vein extended from the posterior mesenteric and united

with the posterior vena cava on the left side, just opposite the right ovarian vein. This connecting branch was not modified from some of the branches of the vena cava normally belonging to this region, since these were all present. It may possibly have been one of the original branches composing the posterior mesenteric which had in some way become attached to the vena cava.



a.b., abnormal connecting vein; *a.m.*, anterior mesenteric vein; *d.*, duodenal vein; *k.*, kidney; *l.-g.*, lieneo-gastric vein; *l.ov.*, left ovarian vein; *p.*, portal vein; *p.m.*, posterior mesenteric vein, *p.v.*, posterior vena cava; *rec.*, rectum; *r.ov.*, right ovarian vein.

Some correlation might be made with the birds, since they have the portal vein and the posterior vena cava normally connected by the posterior mesenteric and the hypogastric veins. Such is, however, not justifiable, for this is, so far as I know, the only record of such an existence in mammals. It is best, therefore, to consider it strictly as an abnormality and in no sense a reversion to some possible past condition.

In conclusion I may add that, though no attempt will be made to account for the causes leading to these abnormalities in cats and rabbits, I do not feel that domestication should be mentioned as a possible cause, since these variations occur as frequently in the wild rabbit as in the domesticated cat.

THE ORIGIN OF THE MIDDLE OCELLUS OF THE ADULT INSECT.

(Preliminary Communication.)

CHUJIRO KOCHI.

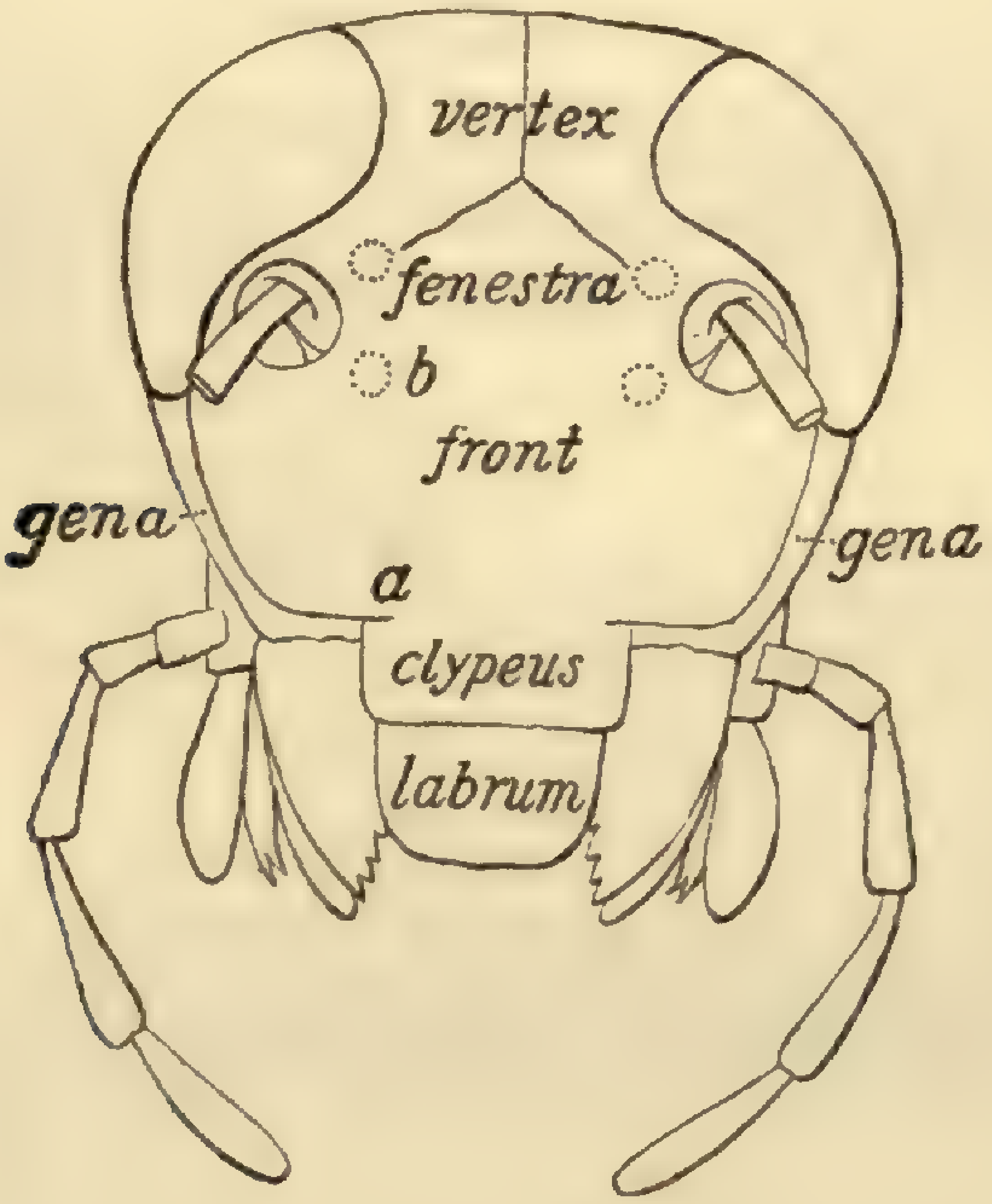
Many years have passed since Leydig and Brandt called attention to the fact that one of the three ocelli in the adult insect situated in its median line was double. I do not know whether there exists to-day any accurate theory of the origin of this middle ocellus. Most entomologists have simply regarded it as the fusion of two ocelli which once occurred separately in the ancestral form. If this theory is true, there must be some relics left in the generalized type of the insect by which we may trace out the original number of the ocelli, *i.e.*, two pairs in all.

Among all the orders of the insects the Orthoptera is perhaps the most generalized one. Among the Orthoptera I shall refer to the cockroach as being one of the oldest, least modified, and, in many ways, very instructive for comparing it with the other specialized forms of insects.

The head of the cockroach (*Blatta orientalis*) is vertically elongated, having a semicircular outline above, and narrowing downwards. The dorsal part of the head is the vertex, and a median suture may be seen traversing it from before backward, and dividing between the eyes into two branches, one of which passes toward the articulation of each antenna to form a *V*-shaped suture. The cephalic portion of this suture is the front, which was called the "clypeus" by Huxley, as well as by Miall and Denny in their work on the anatomy of this insect. Perhaps they did not notice that the clypeus was a small sclerite, situated above the labrum, and separated from the front by a curved suture at the point *a*. This suture also divides the gena from the front on each side of the head.

The basal joint of the antenna is articulated with the front by a transparent flexible membrane, the antennary fossa, and allows of the free play of the antenna. On the inner side of and above the antennary fossa there is a peculiar membranous area of paler color — the fenestra. According to Sedgwick this fenestra is replaced by an ocellus in some cockroaches (the males of Corydia and Heterogamia). If so, we must regard this fenestra as a rudimentary ocellus.

A little below the fenestra, and in the broad, flattened region of the front, there is another peculiar spot marked *b*,



which seems to have escaped the notice of all observers. This spot is, however, more prominent than the fenestra, and it looks like one of the originally paired ocelli, which afterward migrated toward the median line and fused together to form a middle ocellus in other insects.

There often occur some perplexing dark spots in the head of the insects, surrounding their ocelli, but they vary a great deal in size and number as well as in shape and position. But in the cockroach these four spots are always present throughout all the species I have examined. Two of them are regularly situated in the vertex, near its cephalic margin (sometimes they are situated on the boundary line between the vertex and

the front), while the other two are seen in the front, a little below the antenna.

This peculiar appearance of the four spots led me to investigate the occurrence of the original four ocelli. In deciding this question I have made several microtome sections and stained them by the various methods. The preparations have not only shown the connection of the nervous system with these four spots, but their histological characters threw a light upon the nature of their origin as the optical organs.

The complete account of my studies on this subject, with some illustrations, may be published in the near future; therefore I shall leave only the preliminary statement here for the present.

CORNELL UNIVERSITY, ITHACA, N. Y.,
June 10, 1900.

SYNOPSES OF NORTH-AMERICAN INVERTEBRATES.

XII. The Trematodes.

PART I.—THE HETEROCOTYLEA OR MONOGENETIC FORMS.

H. S. PRATT.

The order Trematoda was established in the year 1808 by Rudolphi, who included in it the following genera: *Monostoma* Zeder, *Amphistoma* Rudolphi, *Distoma* Retzius, and *Polystoma* Zeder. During the succeeding half century, when the greatest activity was shown in the description of new species of trematodes, numerous attempts were made by Von Nordmann, Dujardin, Diesing, Leuckart, and others to arrange them in a system of classification which would express their natural relationships. But lack of accurate information on their anatomy and development led, at one time and another, to numerous errors, such as the inclusion among trematodes of pentastomes, planarians, and leeches, and the description of larval forms for adult animals. Thus, it was not until the year 1858 that a system was constructed which was a satisfactory solution of the problem, and the one which is the foundation of the system in general use to-day. In that year P. J. van Beneden proposed the names "Monogenea" for those trematodes which develop without metamorphosis, and "Digenea" for those which develop with metamorphosis, the former being, for the most part, ectoparasites, and the latter, endoparasites. The great additions, however, which have been made in recent years to our knowledge of trematodes have rendered it increasingly difficult to use these distinctions satisfactorily, and consequently, in 1892, Monticelli proposed an entirely new system, in which trematodes are divided into three groups or suborders, the Heterocotylea, Aspidocotylea, and Malacocotylea, the first

of which exactly coincides with the Monogenea of van Beneden, while the second and third are included in the Digenea. This arrangement has been generally adopted by recent authors, and this synopsis is based upon it.

The following are the families, subfamilies, and genera of the suborder Heterocotylea in Monticelli's system of classification, with certain modifications, however, which have been proposed since 1892 by himself, Braun, Cerfontaine, Goto, Saint-Remy, and others:

Order. — Trematoda Rud.

Suborder I. Heterocotylea Mont.

Family I. Temnocephalidæ Hasw.

Subfamily I. Temnocephalinæ Mont.

Genera: Temnocephala, Craspedella, Dactylocephala.

Subfamily II. Actinodactynellinæ Mont.

Genus: Actinodactylella.

Family II. Tristomidæ Taschbg.

Subfamily I. Tristominæ Mont.

Genera: Tristoma, Nitzschia, Epibdella, Phyllonella, Trochopus, Acanthocotyle, Placunella.

Subfamily II. Encotyllabinæ Mont.

Genus: Encotyllabe.

Subfamily III. Udonellinæ Mont.

Genera: Udonella, Echinella, Pteronella.

Family III. Monocotylidæ Taschbg.

Genera: Monocotyle, Calicotyle, Lophocotyle, Dionchus, Merizocotyle, Microbothrium, Pseudocotyle.

Family IV. Polystomidæ Taschbg.

Subfamily I. Polystominæ v. Ben.

Genera: Polystoma, Erpocotyle, Onchocotyle, Diplobothrium, Sphyranura.

Subfamily II. Octocotylinæ v. Ben. et Hesse.

Genera: Octocotyle, Octobothrium, Dactylocotyle, Diclidophora, Anthocotyle, Vallisia, Diplozoön, Phyllocotyle, Hexacotyle, Plectanocotyle, Platycotyle, Pleurocotyle.

Subfamily III. Microcotylinæ Taschbg.

Genera: Microcotyle, Gastrocotyle, Axine, Pseudaxine.

Family V. Gyrodactylidæ v. Ben. et Hesse.

Genera: Gyrodactylus, Dactylogyrus, Tetraonchus, Diplectanum, Calceostoma, Amphibdella, Dactylodiscus, Fridericianella, Anoplodiscus.

Order. — Trematoda Rud.

Small parasitic flatworms, with unsegmented, flattened or cylindrical, unciliated bodies, with usually anterior mouth-opening and bifurcate intestine, and without anal opening, which attach themselves to their hosts by means of suckers, or hooks, or both.

Key to the Suborders.

A_1. Usually ectoparasitic trematodes living upon the external surface or the gills, or in the mouth or cloaca of aquatic animals (except genus Polystoma), to which they attach themselves by means of suckers, or hooks, or both; suckers, when present, are usually near either one or both ends of the body; when at the anterior end, in most cases, a single pair is present; when at the posterior end, in most cases, one or more pairs are present, or, in their place, a sucking disk . . . . Heterocotylea Mont.

A_2. Endoparasitic trematodes which attach themselves to their hosts either by means of one or more median (unpaired) suckers or a large ventral sucking disk; hooks never present.

- B_1. Either a large ventral sucking disk or a mid-ventral row of suckers present; no oral sucker; intestine not bifurcate (except possibly Aspidocotyle) . . . . . . Aspidocotylea Mont.
- B_2. Either one or two or, in a few cases, more than two median suckers present; an oral sucker invariably present (except Gasterostomum); intestine, except in rare cases, bifurcate Malacocotylea Mont.

Key to the Families, Subfamilies, and Genera of the Heterocotylea.

a_1. Body with four to twelve finger-like tentacles at anterior end or on lateral sides, and with a posterior sucker; lives on the outer surface of tropical fresh-water crustaceans and turtles, and in the branchial cavity of a mollusk (Ampullaria) . . Family I. Temnocephalidæ

- b_1. Tentacles all preoral . . . . . Subfamily I. Temnocephalinæ
  - c_1. Tentacles four to six in number; sucker subterminal; two pairs testes.
    - d_1. Dorsal surface without lamellæ; pharynx distinct Temnocephala Blanch. (Fig. 1)
    - d_2. Dorsal surface with several transverse lamellæ; pharynx rudimentary . . . . . Craspedella Hasw. (Fig. 2)
  - c_2. Tentacles twelve in number; sucker very small; one pair lobed testes; pharynx distinct . . . . Dactylocephala Mont.
- b_2. Tentacles not all preoral . . Subfamily II. Actinodactynellinæ

  Tentacles twelve in number at sides and anterior end of pear-shaped

body; 2 pairs testes; sucker-like pit near mouth; mouth with proboscis; pharynx distinct . . . Actinodactylella Hasw. (Fig. 3)

a_2. Body without four to twelve finger-like tentacles.

b_1. Body usually broad and flattened, sometimes elongate or cylindrical, with a single ventral or terminal posterior sucking disk, usually of large size and armed with hooks and with or without radial ridges; paired anterior suckers either present or not.

c_1. Paired anterior suckers present or in their place a pair of projections (or a pair of glandular depressions, Goto)

Family II. Tristomidæ

d_1. Body elliptical or circular and flattened.

e_1. Sucking disk large, with or without radial ridges, and either sessile or with short stalk; genital pores in most cases on left . . Subfamily I. Tristominæ

f_1. Genital pores on left.

g_1. Sucking disk without radial ridges; four eyes.

h_1. Anterior suckers present.

i_1. Body elongate; sucking disk terminal, with (or without, Linton) numerous minute hooks; testes numerous: in branchial cavity of marine fishes

Nitzschia v. Baer (Fig. 4)

i_2. Body elliptical; sucking disk ventral, with three (two, Linton) pairs of hooks of unequal size and often with papillæ; two testes: on the skin of marine fishes

Epibdella Blain. (Fig. 5)

h_2. Anterior suckers not present, in their place a paired membrane; sucking disk with two pairs of hooks; two testes: on the skin of marine fishes

Phyllonella v. Baer (Fig. 6)

g_2. Sucking disk with radial ridges; eyes present or not; anterior suckers present.

h_1. Sucking disk with nine radial ridges and two large hooks; two testes; four eyes; body elliptical: on gills of marine fishes

Tròchopus Dies. (Fig. 7)

h_2. Sucking disk with four to six faintly marked radial ridges and two or three pairs of hooks; two testes; four eyes; body elongate: on skin of marine fishes

Placunella v. Ben. et Hesse (Fig. 8)

h_3. Sucking disk with seven radial ridges;

body very broad, often circular; no eyes; numerous testes: on gills or skin of marine fishes Tristoma Cuv. (Fig. 9)

f_2. Genital pores median or on right. Sucking disk with numerous radial rows of small hooks; anterior suckers present (or in their place a pair of glandular depressions, Goto); numerous testes: on the skin of the skate

Acanthocotyle Mont. (Fig. 10)

e_2. Sucking disk joined to body by a long stalk; genital pores median . . . Subfamily II. Encotyllabinæ

Body elliptical; anterior suckers large, stalked; sucking disk without radial ridges and with two hooks: in mouth of marine fishes

Encotyllabe Dies. (Fig. 11)

d_2. Body elongate, cylindrical, and sometimes ringed; sucking disk terminal, without radial ridges or hooks; pharynx extensible; genital pores median; no eyes: on parasitic crustaceans . . . . . Subfamily III. Udonellinæ

e_1. Anterior suckers present; body ringed in youth; pharynx without hooks; one testis: on Caligus and Anchorella. . . . . Udonella Johnst. (Fig. 12)

e_2. Anterior suckers absent, but in their place a pair of projections: on Caligus.

f_1. Body ringed; anterior projections narrow, tentacle-like; pharynx with two hooks

Echinella v. Ben. et Hesse (Fig. 13)

f_2. Body ringed in youth, swollen in middle; anterior projections broad, membranous; pharynx without hooks, but with a large number of minute rods

Pteronella v. Ben. et Hesse (Fig. 14)

c_2. Paired anterior suckers or projections absent; sucking disk with or without radial ridges; body flattened and usually broad

Family III. Monocotylidæ

d_1. Sucking disk very small, without radial ridges or hooks: on skin of selachians.

e_1. Body elliptical, with truncated ends; vagina paired; testes usually numerous

Pseudocotyle v. Ben. et Hesse (Fig. 15)

e_2. Body elliptical, with attenuated ends; vagina unpaired, opening on left of ventral surface; one large testis.

Microbothrium Ols. (Fig. 16)

d_2. Sucking disk large, with radial ridges and (except in Lophocotyle) two hooks; paired adhesive glands at anterior end.

e_1. Anterior glandular areas large and prominent, one on each side of anterior end.

f_1. Body elongate; sucking disk nearly circular and containing one central, eighteen peripheral, and seven intermediary depressions; one very large testis: on skin of skates

Merizocotyle Cerf. (Fig. 17)

f_2. Body elongate; four eyes; sucking disk elliptical, with ten radial ridges; two testes; no vagina: on gills of Remora . . Dionchus Goto (Fig. 18)

f_3. Body ovoid; sucking disk circular, with numerous radial ridges, with no large, but a group of minute, hooks on its edge; testes numerous: on skin of marine fishes . . Lophocotyle Braun (Fig. 19)

e_2. Anterior glandular areas inconspicuous.

f_1. Body heart-shaped; sucking disk with seven radial ridges; testes numerous: on skin and in the cloaca of marine fishes

Calicotyle Dies. (Fig. 20)

f_2. Body elongate; sucking disk with eight radial ridges; three testes: on skin of marine fishes

Monocotyle Taschbg. (Fig. 21)

b_2. Body usually elongate and flattened, though sometimes broad, with a more or less distinct disk-like region at hinder end, bearing either suckers, or hooks, or both; paired anterior suckers either present or absent.

c_1. Posterior disk-like region with suckers, usually paired, and, in most cases, with hooks; anterior paired suckers either present or absent.

d_1. Posterior region with either two or six suckers; paired anterior suckers absent . . Subfamily I. Polystominæ

e_1. Posterior region with two (one pair) large suckers and two large hooks; body elongate: on skin of Necturus . . . . Sphyranura R. R. Wr. (Fig. 22)

e_2. Posterior region with six (three pairs) suckers and with or without a terminal projection.

f_1. Posterior region without a terminal projection; body rather broad; vagina paired, with an opening on either side of body: on gills and in urinary bladder of amphibians, and in mouth, nose, and urinary bladder of turtles

Polystoma Zeder (Fig. 23)

f_2. Posterior region with a terminal projection.

g_1. Posterior disk-like region bearing the suckers is oval, the terminal projection is rather wide

and bears two hooks; body elongate: on gills of Mustelus

Erpocotyle v. Ben. et Hesse (Fig. 24)

g_2. Suckers stalked; terminal projection narrow, with four hooks; body attenuated: on gills of Accipenser

Diplobothrium F. S. Leuck. (Fig. 25)

g_3. The terminal projection is bifid at its extremity, each half bearing a small sucker; body elongate: on gills of selachians

Onchocotyle Dies. (Fig. 26)

d_2. Posterior region with four to eight large suckers; paired anterior suckers present . Subfamily II. Octocotylinæ

e_1. Posterior region with four (five) suckers.

f_1. Posterior region with two pairs of suckers at the end of long stalks; body elongate: on gills of marine fishes

Platycotyle v. Ben. et Hesse (Fig. 27)

f_2. Posterior region with four suckers in a lateral, longitudinal row, to which may be added a fifth smaller sucker on the opposite side; body elongate and asymmetrical: on gills of marine fishes (Scomber) . . . Pleurocotyle Gerv. (Fig. 28)

e_2. Posterior region with six (three pairs) suckers.

f_1. Body elongate; posterior region with the six suckers bears at its posterior end a tail-like projection, at the extremity of which is a single sucker: on gills of marine fishes

Phyllocotyle v. Ben. et Hesse (Fig. 29)

f_2. Body either elongate or broadly elliptical; suckers on the broad posterior margin, in the median line of which, between the median suckers, a pair of hooks on a short projection may or may not be present: on gills of marine fishes

Plectanocotyle, Dies. (Fig. 30)

e_3. Posterior region with eight (four pairs) suckers.

f_1 Individuals fused together, *x*-shaped, in pairs; body elongate; posterior suckers sessile: on gills of fresh-water fishes Diplozoön v. Nordm. (Fig. 31)

f_2. Individuals not fused together in pairs.

g_1. Body asymmetrical, elongate, composed of two equal portions, which form an angle with each other; posterior suckers sessile: on gills of Lichia

Vallisia Par. et. Per. (Fig. 32)

g_2. Body symmetrical.

h_1. Posterior suckers alike in size.

i_1. Posterior region with median hooks at or near its posterior end; genital hooks with simple points.

j_1. Body usually elongate; posterior suckers with short stalks; intestinal crura do not anastomose; genital hooks arranged in groups; vagina dorsal: on gills of marine fishes, especially the Clupidæ

Octobothrium F. S. Leuck. (Fig. 33)

j_2. Body usually elongate, thick; posterior suckers usually sessile; genital hooks arranged in two lines in pairs; no vagina: on gills of marine fishes, especially the Scomberidæ

Octocotyle Dies. (Fig. 34)

i_2. Posterior region without median hooks; genital hooks with double points and arranged in a circle.

j_1. Body usually elongate; suckers at the end of long stalks and functioning as pincers; vagina ventral: on gills of marine fishes, especially the Gadidæ

Dactylocotyle v. Ben. et Hesse (Fig. 35)

j_2. Body usually elongate; suckers either stalked or not, and functioning as suckers, each sucker having a characteristic chitinous framework in form of a Greek cross; no vagina: on gills of marine fishes, especially the Sparidæ

Diclidophora (Dies.) Goto (Fig. 36)

h_2. Posterior suckers not alike in size, one pair differing from the others.

i_1. Body elongate; anterior pair of posterior suckers very large, at a distance from the others, projecting from the side of the body; the other three pairs minute, stalked, and grouped

together at the extremity of the body: on gills of marine fishes

Anthocotyle v. Ben. et Hesse (Fig. 37)

i_2. Body elongate; anterior end pointed; posterior end bearing eight sessile suckers at extremity of body, the median pair being smaller than the others: on gills of marine fishes

Hexocotyle Blain. (Fig. 38)

d_3. Posterior region elongate, and bearing numerous small suckers, either paired or not; paired anterior suckers present . . . . Subfamily III. Microcotylinæ

e_1. Body usually symmetrical; posterior suckers paired, numbering from 10 to 120 on a side; no hooks: on gills of marine fishes

Microcotyle v. Ben. et Hesse (Fig. 39)

e_2. Body asymmetrical, one lateral side being more developed than the other, and bearing most or all of the suckers.

f_1. Body tapering anteriorly, widening towards the hinder end, the latter forming, by a one-sided lateral expansion, a broad asymmetrical terminal disk bearing small suckers along its margin.

g_1. Numerous suckers along the longer side of the terminal disk, a small number or none along the other side; no hooks present: on the gills of marine fishes

Axine Abild. (Fig. 40)

g_2. A single row of suckers along the terminal disk, which is prolonged into a spatula-shaped appendix bearing two hooks: on gills of marine fishes (Caranx)

Pseudaxine Par. et Per. (Fig. 41)

f_2. Anterior end of body attenuate, hinder two-thirds widened on one side, on the margin of which is a row of small suckers; hooks present at the posterior end: on the gills of marine fishes

Gastrocotyle v. Ben. et Hesse (Fig. 42)

c_2. Posterior region usually disk-like, without suckers, but with hooks . . . . Family V. Gyrodactylidae

d_1. Two or four short tentacle-like projections at anterior end of body; posterior disk with two large central hooks and numerous small marginal ones; worms minute: on skin and gills of fresh-water and marine fishes.

e_1. Two short anterior projections; posterior disk with usually sixteen marginal hooks; no eyes
Gyrodactylus v. Nordm. (Fig. 43)

e_2. Four short anterior projections; posterior disk with usually fourteen marginal hooks; four eyes
Dactylogyrus Dies. (Fig. 44)

d_2. No tentacle-like anterior projections.

e_1. A pair of anterior suckers present; posterior end extended transversely, with four marginal hooks: on the gills of marine fishes
Diplectanum Dies. (Fig. 45)

e_2. No anterior suckers present.

f_1. Posterior region with four large central hooks.

g_1. Body contracted posteriorly; posterior disk with a number (12–16) of small marginal hooks; anterior end triangular, with four slight projections: usually on gills of fresh-water fishes . Tetraonchus Dies. (Fig. 46)

g_2. Body elongate; posterior region trilobed, with twelve minute marginal hooks: on gills of Torpedo . Amphibdella Chatin (Fig. 47)

g_3. Posterior disk stalked, with lobed margin and no marginal hooks: on gills of Coregonus
Dactylodiscus Ols. (Fig. 48)

f_2. Posterior region with no large central hooks or with but one.

g_1. Broad, paired, membrane-like projection at anterior end; posterior disk terminal, either unarmed, with minute hooks, or with a single large central hook; body elongate, cylindrical: on gills of marine fishes
Calceostoma v. Ben. (Fig. 49)

g_2. A pair of glandular areas at anterior end; posterior disk terminal, irregularly elliptical, with minute hooks in center; a prominent glandular projection in middle of right side of body: on eggs of a fresh-water fish in Brazil . . Fridericianella Brds. (Fig. 50)

g_3. Two sucker-like depressions at anterior end; posterior disk without hooks: on gills of Pagrus . . . . Anoplodiscus Sonsino.

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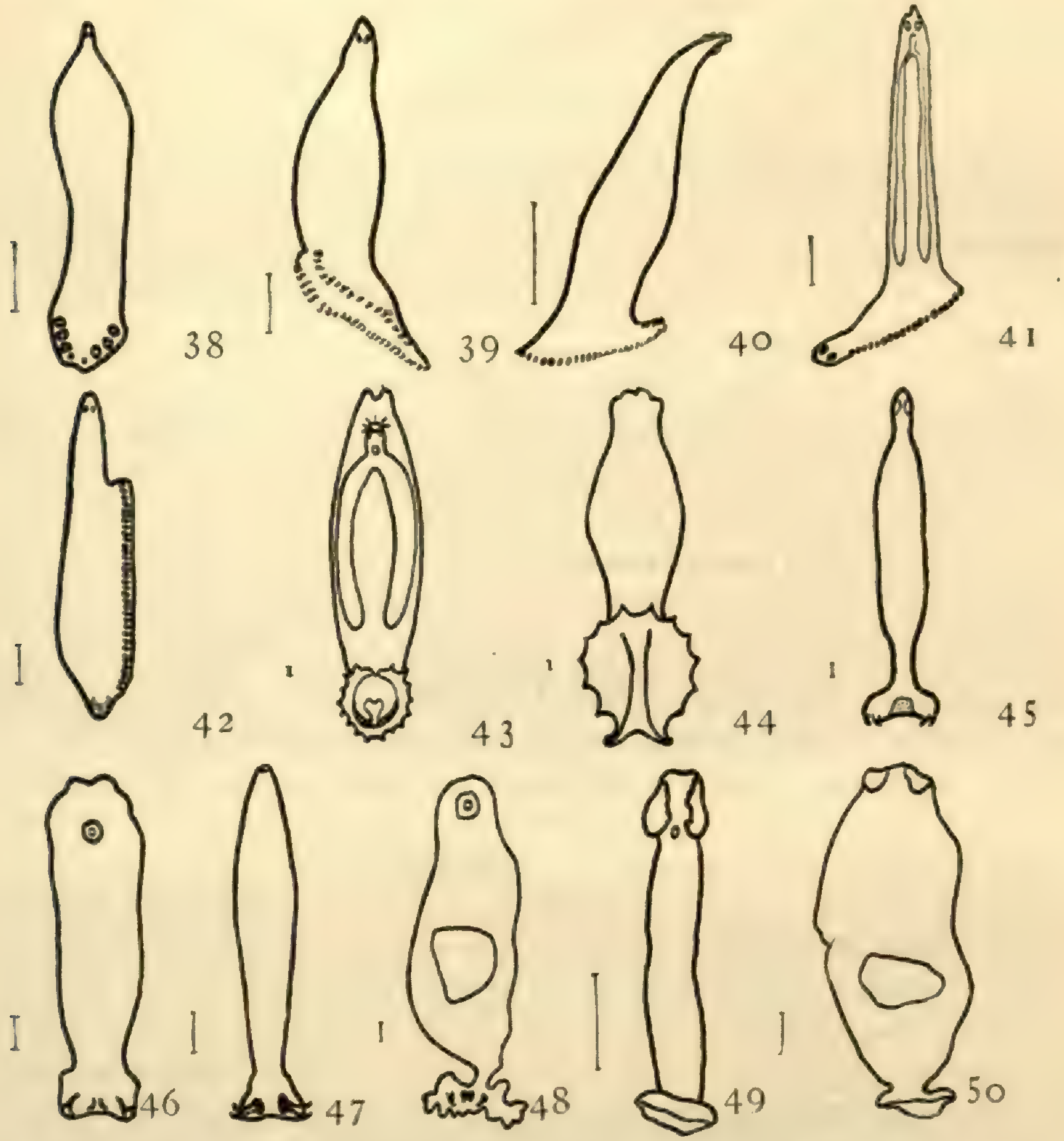

The line to the left of the figures indicates the actual size of the animal. The measurements given in the keys, and upon which these lines are based, are usually maximum measurements. The softness and changeable form of the trematode make accurate measurements difficult.

(1) Temnocephala mexicana; (2) Craspedella spenceri; (3) Actinodactylella blanchardi; (4) Nitzschia elongata; (5) Epibdella bumpusii; (6) Phyllonella soleæ; (7) Trochopus tubiporus; (8) Placunella pini; (9) Tristoma coccineum; (10) Acanthocotyle verrilli; (11) Encotyllabe nordmanni; (12) Udonella caligorum; (13) Echinella hirundinis; (14) Pteronella molvæ; (15) Pseudocotyle squatinæ; (16) Microbothrium apiculatum; (17) Merizocotyle diaphanum; (18) Dionchus agassizi; (19) Lophocotyle cyclophora; (20) Calicotyle kroyeri; (21) Monocotyle myliobatis; (22) Sphyranura osleri; (23) Polystoma hassalli; (24) Erpocotyle lævis; (25) Diplobothrium armatum; (26) Onchocotyle canis; (27) Platycotyle gurnardi; (28) Pleurocotyle scombri; (29) Phyllocotyle gurnardi; (30) Plectanocotyle elliptica; (31) Diplozoön paradoxum; (32) Vallisia striata; (33) Octobothrium sagittatum; (34) Octocotyle scombri; (35) Dactylocotyle denticulatum; (36) Diclidophora affinis; (37) Anthocotyle merluccii; (38) Hexacotyle thunninæ; (39) Microcotyle longicauda; (40) Axine heterocerca; (41) Pseudaxine trachuri; (42) Gastrocotyle trachuri; (43) Gyrodactylus grœnlandicus; (44) Dactylogyrus auriculatus; (45) Diplectanum sciænæ; (46) Tetraonchus momenteron; (47) Amphibdella torpedinis; (48) Dactylodiscus borealis; (49) Calceostoma elegans; (50) Fridericianella ovicola.

Key to the Species of North-American Heterocotylea.

Genus Temnocephala.

Body ovoid; tentacles five in number, long and slender; pharynx very large, intestine short but broad, with a pair of lateral anterior projections; .5–1 mm. long, .2 mm. wide: on carapace of Cambarus Digueti (Mexico)
T. mexicana Vayssière (Fig. 1)

Genus Epibdella.

Body flat, smooth, ovate, slightly constricted behind the anterior suckers; anterior suckers crossed by twenty-two ribs; posterior sucker attached by pedicel at posterior margin of body, elliptical, with four hooks; 12.5 mm. long, 8.35 mm. wide: on skin of *Dasyatis centura* (Woods Holl)
E. bumpusii Linton (Fig. 5)

Genus Tristoma.

a_1. Diameter of sucking disk less than a third the length of the body.

- b_1. Body ovate; sucking disk small, less than a quarter the length of body and but little larger than the anterior suckers; 10 mm. long, 7 mm. wide: on gills of *Tetrapturus albidus*
T. cornutum Verrill
- b_2. Body heart-shaped; color white, with small oval spots on the dorsal surface; anterior end between the anterior suckers fringed; 22.5 mm. long, 18 mm. wide: on the body of Diodon (California)
T. maculatum Rud.
- b_3. Body nearly circular, ventral periphery with short, radial rows of papillæ, and dorsal surface with several series of pointed black papillæ; sucking disk with crenulate border, and not reaching the posterior end of body; 15 mm. long, 12 mm. wide: on gills of sword fish (Woods Holl, Linton) . . *toccineum Cuv.* (Fig. 9)

a_2. Diameter of sucking disk equals one-third or half the length of body.

- b_1. Body circular, ventral surface covered with papillæ; sucking disk large, its diameter equaling half the length of the body, and with a large central area; 15 mm. long, 14 mm. wide: on gills of *Tetrapturus albidus* (Woods Holl, Linton) . *T. læve* Verrill
- b_2. Body almost circular, slightly attenuate forward; sucking disk large, its diameter equaling one-third the length of body, and with a plicate membranous border; 18 mm. long, 19 mm. wide: on *Mola mola* (Woods Holl, Linton) . . . . . . *T. molæ* Blanch.

Genus Nitzschia.

a_1. Body lanceolate, reddish, contracted posteriorly; sucking disk globose; anterior suckers large, linear, oblique; mouth triangular; 16 mm.

long, 5 mm. wide; from gills and under the opercles of sturgeon (Woods Holl, Linton, etc.) . . . . *N. elongata* Nitzsch (Fig. 4)

a_2. Body linear, contracted posteriorly, very small; anterior portion papillose; sucking disk not globose; 1.9 mm. long, .5 mm. wide: from cod (Woods Holl) . . . . *N. papillosa* Linton

Genus Acanthocotyle.

Body linear; anterior end blunt with a pair of glands and without anterior suckers; sucking disk large, circular, as wide as the body, with thirty-four radial rows of hooks; about thirty-seven testes; 5 mm. long, 1.2 mm. wide: on skin of skate (Cape Cod) . *A. verrilli* Goto (Fig. 10)

Genus Dionchus.

Intestine bifurcate, distal ends fused; anterior end of body triangular, with two groups of glands; genital pore minute, on left side of ventral surface, near mouth; 2 mm. long, .5 mm. wide (Newport)

D. agassizi Goto (Fig. 18)

Genus Polystoma.

a_1. Posterior disk-like region attached to body between the two anterior pairs of suckers.

b_1. Body elongate, lanceolate; disk wider than body; three pairs minute hooks between anterior pair of suckers, one large and two small pairs between posterior pair of suckers; 6 mm. long: in the nose of the food terrapin . . . *P. coronatum* Leidy

b_2. Body broad, tapering forward; disk hexagonal; testis a large slightly lobed body in center of body; three pairs small hooks between anterior pair of suckers, and three pairs of small and one pair large hooks between posterior pair of suckers; intestine bifurcate, unbranched; 1.5 mm. long, 1 mm. wide: from urinary bladder of *Kinosternon pennsylvanicum*

P. hassalli, Goto (Fig. 23)

a_2. Posterior disk-like region, attached at its anterior end to body; body elliptical; intestine bifurcate, unbranched; penis provided with sixteen spines, alternately small and large; 2.5 mm. long, 1 mm. wide: in urinary bladder of musk turtle (*Aromochelys odoratus*)

P. oblongum R. R. Wr.

Genus Spyranura.

Body elongate, contracted anteriorly and posteriorly just before disk, which is wider than body and bears two large suckers; intestine bifurcate, unbranched; testes numerous; 4 mm. long, .6 mm. wide: on skin of Necturus . . . . *S. osleri* R. R. Wr. (Fig. 22)

GENUS OCTOBOTHRIUM.

Body sagittate, tapering anteriorly ; posterior suckers on a distinct disk which is not so wide as the body ; 6 mm. long, 2 mm. wide : on gills of *Castastomus teres* (R. R. Wright) *O. sagittatum* F. S. Leuck.[1] (Fig. 33)

GENUS OCTOCOTYLE.

Body elongate, lanceolate ; anterior suckers elongate, posterior suckers small, slightly stalked, in two rows ; genital pore with two longitudinal rows of six (five) small hooks each ; two pairs of hooks between posterior pair of suckers ; 5 mm. long, .6 mm. broad : on gills of mackerel (Newport, Goto) . . . . *O. scombri* Kuhn (Fig. 34)

GENUS DACTYLOCOTYLE.

Body lanceolate ; anterior portion of each posterior sucker with numerous denticulate papillæ ; 8 mm. long, 2 mm. wide : on gills of the pollack (Woods Holl, Linton) . . . . *D. denticulatum* Ols. (Fig. 35)

GENUS DICLIDOPHORA.

Body elongate, spatulate, anterior portion elliptical, posterior portion cylindrical ; posterior suckers on long stalks ; cirrus armed with fifteen bifurcate hooks ; 12–40 mm. long : from the mouth of flounder (Woods Holl) . . . . *D. offinis* Linton (Fig. 36)

GENUS MICROCOTYLE.

a_1. Testes not numerous, twelve to fifteen in number, median in hinder part of body.
- b_1. Testes about twelve in number, in front of which is ovary ; length of sucker-bearing region about one-third that of body, with about forty-six pairs of suckers ; 2.5 mm. long, .6 mm. wide : on gills of Scup (Newport) . . . . *M. stenotomi* Goto
- b_2. Testes about fifteen in number, in front of which is ovary ; length of sucker-bearing region about one-fourth that of body, with about twenty-three pairs of suckers ; 2.5 mm. long, 6 mm. wide : on gills of blackfish (Newport) . . . . . *M. hiatulæ* Goto

a_2. Testes numerous, fifty to fifty-five in number, median in hinder part of body.
- b_1. Testes about fifty in number, in front of which is ovary ; length of sucker-bearing region about one-third that of body, with about seventy pairs of suckers ; 4 mm. long, 1 mm. wide : on gills of bluefish (Newport) . . . . *M. pomatomi* Goto

[1] The systematic position of this species is uncertain.

b_2. Testes about fifty-five in number, in front of which is ovary ; length of sucker-bearing region about seven-elevenths that of body, with about 120 pairs of suckers ; 7 mm. long, 2 mm. wide : on gills of weakfish (Newport) . *M. longicauda* Goto (Fig. 39)

Genus Gyrodactylus.

Body elongate, elliptical, mouth surrounded by a row of spines ; posterior disk round ; the large central hooks have each double tubercles on its base ; 1 mm. long, .2 mm. wide : on *Cottus scorpius*
G. grœnlandicus Lev. (Fig. 43)

Genus Plectanocotyle.

Body elliptical, broad ; mouth terminal ; no median posterior projection or hooks ; 4 mm. long, 2 mm. wide : on gills of *Rocus americanus*
P. elliptica Dies. (Fig. 30)

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REVIEWS OF RECENT LITERATURE.

ZOÖLOGY.

Garman's Deep-Sea Fishes. — The most important work in ichthyology for the past year is Mr. Samuel Garman's monumental report on the deep-sea fishes collected off the western equatorial coasts of America and off the Galapagos Islands. It is based on the specimens obtained by the steamer *Albatross* in the winter of 1891, while under the direction of Professor Alexander Agassiz. This report contains an annotated list of the species obtained, 176 of them new to science, together with a supplementary volume of plates, in which most of the species are beautifully figured. The general report is preceded by a valuable discussion of the distribution of the deep-sea fishes, and it is followed by an anatomical paper on the lateral line in fishes, its function and significance.

The species added to the fauna of Middle America are the following:

Raja badia.
Raja alia (Yucatan = *R. achleyi* G. and B., not Garman).
Centroscyllium nigrum.
Isistius (rather *Leius*) *brasiliensis* (Q. and G.).
Liopropoma longilepis.
Centristhmus signifer (new genus allied to Anthias).
Pontinus furcirhinus.
Ectreposebastes imus (new genus allied to Scorpæna).
Hoplostethus pacificus.
Trachichthys mento.
Caulolepis subulidens.
Melamphaës mizolepis (Günther).
Melamphaës (*Plectromus*) *nigrofulvus.*
Melamphaës maxillaris.
Melamphaës frontosus.
Gempylus thyrsitoides (Lesson) (= *G. serpens* C. and V.).
Trichiurus nitens.
Teuthis elegans.
Chiasmodon subniger.
Lophiomus spilurus.
Lophiomus caulinaris (*L. setigerus* Gilbert; Jordan and Evermann; not of Wahl — a Japanese species).
Dolopichthys allector (new genus, near Ceratias).
Chaunax coloratus (type of subgenus Chaunacops).
Oncocephalus porrectus.
Halieutopsis tumifrons (new genus, near Halieutæa).
Dibranchus hystrix.
Dibranchus scaber.
Dibranchus asper.
Dibranchopsis (new genus for *Halieutæa spongiosa* Gilbert).
Dibranchichthys nudivomer.
Malthopsis sparsa.
Malthopsis erinacea.

Malthopsis spinosa.
Malthopsis spinulosa.
Prionotus frontalis.
Peristedium barbigerum.
Peristedium crustosum.
Careproctus longifilis (Garman, 1892).
Paraliparis fimbriatus (Garman, 1892).
Paraliparis grandiceps.
Paraliparis attenuatus.
Paraliparis angustifrons.
Paraliparis latifrons.
Callionymus atrilabiatus.
Entomacrodus cruentatus.
Bothrocaropsis alalonga (new genus, near Maynea).
Bothrocaropsis rictolata.
Bothrocaropsis elongata.
Gymnelis conorhynchus.
Lycodopsis scaurus.
Lycodes anguis.
Lycodes serpens.
Lycodes incisus.
Lycodes cicatrifer.
Phucocœtes suspectus.
Maynea bulbiceps.
Leucicorus lusciosus (new genus of Brotulidæ).
Mixonus caudalis.
Dicrolene filamentosa.
Dicrolene nigra.
Dicrolene pullata.
Porogadus longiceps.
Porogadus atripectus.
Porogadus breviceps.
Monomitopus torvus.
Monomeropus malispinosus.
Bassozetus nasus.
Diplacanthopoma jordani.
Holcomycteronus digitatus (new genus of Brotulidæ).
Eretmichthys pinnatus (new genus of Brotulidæ).
Eretmichthys ocella.
Catætyx simus.
Pseudonus acutus (new genus of Brotulidæ).
Acanthonus spinifer.
Sciadonus pedicellaris (new genus of Brotulidæ).
Lamprogrammus illustris.
Microlepidium grandiceps (new genus, near Lepidion).
Leptophycis filifer (new genus, near Lepidion).
Merluccius angustimanus.
Antimora rhina.
Læmonema gracilipes.
Phyciculus longipes.
Bregmaceros longipes.
Macrurus bulbiceps.
Macrurus bucephalus.
Macrurus liraticeps.
Macrurus barbiger.
Macrurus capito.
Macrurus leucophæus.
Macrurus boops.
Macrurus fragilis.
Macrurus carminifer.
Macrurus gracilicauda.
Macrurus orbitalis.
Macrurus loricatus.
Macrurus cuspidatus.
Macrurus convergens.
Macrurus latirostratus.
Macrurus anguliceps.
Macrurus latinasutus.
Macrurus trichiurus.
Macrurus tenuicauda.
Macrurus canus.
Hippoglossina vagrans.
Citharichthys maculifer.
Monolene maculipinna.
Monolene dubiosa.
Symphurus varius.
Symphurus microlepis.
Sternoptyx obscura.
Argyropelecus lychnus.
Argyropelecus caninus.

Argyropelecus affinis (= *A. hemigymnus* G. and B., not type).
Polyipnus laternatus (from Barbados = *P. spinosus* G. and B., not type).
Valenciennellus stellatus.
Maurolicus oculatus.
Maurolicus lucetius.
Lychnopoles argenteolus (new genus, near Gonostoma).
Cyclothone signata.
Cyclothone acclinidens.
Synodus simulans.
Synodus acutus.
Chlorophthalmus mento.
Scopelengys dispar.
Bathypterois ventralis.
Bathypterois pectoralis.
Ipnops agassizii.
Myctophum oculeum.
Myctophum tenuiculum.
Myctophum luminosum.
Myctophum aurolaternatum.
Myctophum nitidulum.
Myctophum laternatum.
Myctophum atratum.
Chauliodus barbatus.
Chauliodus dentatus.
Stomias colubrinus.
Stomias hexagonatus.
Stomias atriventer.
Dactylostomias filifer (new genus, near Stomias).
Leptochilichthys agassizii (new genus, near Alepocephalus).
Bathytroctes alvifrons.
Bathytroctes alveatus.
Bathytroctes inspector.
Narcetes pluriserialis.
Alepocephalus asperifrons.
Alepocephalus convexifrons.
Alepocephalus fundulus.
Halosaurus attenuatus.
Halosaurus radiatus.
Notacanthus spinosus.
Uroconger varidens.
Congermuræna (*Congrellus*) *caudalis.*
Congrosoma evermannii.
Ophichthys (*Cryptopterus*) *frontalis.*
Ophichthys biserialis.
Echidna cocosa.
Echidna scabra.
Xenomystax rictus.
Chlopsis gilbertii.
Venefica ocella.
Venefica tentaculata.
Serrivomer sector.
Labichthys bowersii.
Nemichthys fronto.
Atopichthys esunculus (group name for larval eels, of unknown relations).
Atopichthys sicarius.
Atopichthys cinctus.
Atopichthys dentatus.
Atopichthys falcidens.
Atopichthys acus.
Atopichthys ophichthys.
Atopichthys cingulus.
Atopichthys lychnus.
Atopichthys obtusus.
Atopichthys longidens.
Myxine circifrons.
Myxine acutifrons.

Mr. Garman shows that the name "Homea, Fleming" is prior to both Heptatrema (Voigt, 1832) and Bdellostoma (Müller, 1834). It should, therefore, take the place of both of these. It may be also noted (p. 223) that, in the original description of Engyophrys, Jordan and Bollman, "cycloid" was a slip of the pen for "ctenoid."

Mr. Garman completes his work with a most useful list of the

deep-sea fishes of the world, with a table showing their distribution. A full bibliography and a number of other useful tables are also included.

D. S. J.

Jenkins on Labroid Fishes of Hawaii. — In the *Bulletin of the United States Fish Commission* Dr. Oliver Peebles Jenkins, of Stanford University, gives an account of new species of labroid fishes obtained by him and by others in Honolulu in 1889 and later. The chief collection was made by Dr. Jenkins and his assistant, Dr. George C. Price, under the auspices of De Pauw University. Later, both Dr. Jenkins and Dr. Price were called to Stanford University, and the original collection of fishes, by far the largest yet made about the Hawaiian Islands, was supplemented by others, the principal one being made by Dr. Thomas D. Wood, also of Stanford University.

In the single group of Labridæ and Scaridæ twenty-two new species were obtained. These are described and figured in the present paper. These new species are the following:

Macropharyngodon aquilolo.
Halichœres iridescens.
Halichœres lao.
Hemicoris remedius.
Coris lepomis.
Hemicoris keleipionis.
Thalassoma pyrrhovinctum.
Novaculichthys woodi.
Novaculichthys entargyreus.
Hemipteronotus umbulatus.
Iniistius leucozonus.
Iniistius verater.
Cheilinus zonurus.
Pseudocheilinus octotænia.
Anampses evermanni.
Calotomus irradians.
Scarus brunneus.
Scarus gilberti.
Scarus paluca.
Scarus ahula.
Scarus miniatus.
Pseudoscarus jordani.

This list indicates the extreme richness of the Hawaiian fish fauna, its isolation and distinctness as compared with the fauna of the East Indies, and the fact that the few collections yet made about Honolulu have barely touched the wealth of the whole.

D. S. J.

Greene on the Caudal Heart of the Hagfish. — In the *American Journal of Physiology* Dr. Charles Wilson Greene gives his studies on the caudal heart in the California hagfish, *Polistotrema stouti.* This structure was first discovered by Retzius in 1890, who accidentally noticed a paired pulsating organ in the tail of the slime eel (Myxine). The function of this structure is to drive the blood of the subcutaneous spaces back into the circulatory system.

We are pleased that Dr. Greene calls this curious animal by its

actual scientific name. Bdellostoma, like Amphioxus, has its place in the history of anatomy, but neither of these terms is the scientific name of anything, any more than lancelet is, or hag. Branchiostoma is the scientific name of the chief genus of lancelets.

Homea is the name of this group of hagfishes, Heptatrema and Bdellostoma being later synonyms of the same, with no standing in scientific nomenclature. For the species of Homea, with an increased number of gill openings, Dr. Gill has proposed the name of "Polistotrema." There are two species of Polistotrema, *P. dombey* of Chili and *P. stouti* of California. These are not very much unlike and may be really the same thing, though the balance of evidence at present favors their distinction as species. If one does not recognize the genus Polistotrema, the California hagfish, which is rapidly taking its place among the anatomical classics, must be *Homea stouti.*

D. S. J.

Jordan and Snyder on Fishes of Mexico.— In the winter of 1899–1900 Messrs. Jordan and Snyder made a large collection of fishes in the fresh waters of Mexico, especially about Guadalajara, Mexico, Aguas Calientes, Puente de Ixtla, San Luis Potosi, and Tampico. Forty species were taken, twenty of them being new to science, and four new genera, Istlarius (Siluridæ), Xystrosus, Falcula (Cyprinidæ), and Xenendum (Pœciliidæ).

The collection indicates that the river fauna of Central Mexico is far more abundant and characteristic than had been hitherto supposed. A most unexpected fact was the large number of very closely related species of Pescado del Rey, or Pescados Blancos, found in the great lake of Chapala. All are alike excellent as food, rich and delicate in flavor. The new species are all figured. These are the following:

Istlarius balsanus, a large catfish from Rio Ixtla, south of the volcanoes in Morelos.

Notropis rasconis, Rio Verde (Rascon), near San Luis Potosi.

Notropis calientes, Rio Verde de las Aguas Calientes.

Xystrosus popoche, Lake Chapala.

Falcula chapalæ, Lake Chapala.

Characodon encaustus, Lake Chapala.

Xenendum caliente, Aguas Calientes.

The genus Xenendum is allied to Goodea, but with bifurcate teeth, which, as in Goodea, are loosely attached. The intestines are very long, as in Pœcilia, but the sexes are similar.

Xenendum xaliscone, Lake Chapala.
Pœcilia limantouri, Rio Ixtla, Tampico, and Rascon.
Xiphophorus montezumæ, Rascon.
Eslopsarum arge, Aguas Calientes. *Chirostoma breve* Steindachner is an Eslopsarum and identical with the earlier named *E. jordani*.
Chirostoma chapalæ.
Chirostoma crystallinum.
Chirostoma lermæ; this species has been recently described by Dr. Boulenger as *C. sphyræna*, also from Lake Chapala specimens. Dr. Boulenger's name takes precedence.
Chirostoma diazi; this is *C. lucius* Boulenger, a prior name.
Chirostoma ocotlane.
Chirostoma promelas. All these species of Chirostoma are from Lake Chapala, near Ocotlan in Jalisco.
Xeros istlanus, Puente de Ixtla.
Neetroplus carpintes, Lake Carpinte, Tampico.
Cichlasoma steindachneri, Rascon.

D. S. J.

Notes on Recent Fish Literature. — Dr. Louis Dollo, of Brussels, describes a new genus of trachinoid fishes collected by M. E.-G. Racovitza, naturalist of the Belgian Antarctic Commission. To it he applies the name of *Cryodraco antarcticus*. The type came from a depth of 450 meters, in the Antarctic Ocean (Lat. 71° 22′ S., Long. 88° 38′ W.).

Mr. Edgar W. Waite gives an account of an "oarfish," or "king of the herrings" (*Regalecus glesne ?*), taken near Port Jackson in Australia. The species of this rare and interesting deep-water genus have not been adequately determined, and Mr. Waite's paper will prove valuable for future comparisons.

In the *Anales del Museo Nacional de Buenos Aires* Dr. Carlos Berg publishes valuable notes on various fishes — Exomegas, Polyprion, Curimata, Ilisha, Crenicichla, etc. He shows that the name *Ilisha orbignyana* should replace that of *Ilisha flavipinnis*, adopted by Jordan and Evermann. The identity of *Cottoperca rosenbergi* with *Aphritis gobio* is also shown, the species standing as *Cottoperca gobio*.

Dr. L. Berg, of the University of Moscow, has published in the *Proceedings of the Caucasian Museum* at Tiflis an account, in Russian and in German, of the fishes collected by Dr. G. Radde, director of the museum at Tiflis. Thirty-one species are included, one of them being regarded as a new "variety."

In the *Transactions of the London Zoölogical Society* Dr. Boulenger gives a second account of the rich fish fauna of Lake Tanganyika, from the collections of the Lemaire Expedition. A number of new genera and species of Cichlidæ are described and well figured, three of the plates being in colors, the work of the artist of the expedition, M. Dardenne.

In the *Proceedings of the Scientific Society of Christiania* Dr. Robert Collett discusses in detail the relations of *Lycodes gracilis*, a fish of the arctic parts of the Atlantic. Several figures are given, together with detailed description. Dr. Collett regards *L. perspicillum* as probably the young of *L. reticulatus*, *L. rossi* as probably the very young of *L. pallidus*, and *L. zoarchus*, from Nova Scotia, as certainly the young of *L. gracilis*. These conclusions differ somewhat from those of Dr. Smith, noted a few months since.

The species of filefish described by Jordan and McGregor from Clarion Island, Mexico, under the name of *Cantherines carolæ*, proves to be identical with the type of Cantherines, *C. sandwichiensis* Quay and Gaimard of Hawaii, a fact first pointed out by Mr. R. E. Snodgrass. It is not evident that either *C. pullus* of the West Indies, or *C. pardalis* of the East Indies, is really different from *C. sandwichiensis.*

In a private letter Professor D'Arcy W. Thompson, of University College, Dundee, corrects the current account of the genus Eumesogrammus. The type *E. præcisus* has four lateral lines, not three, the fourth being a ventral branch, accessory to the third, and running from the breast to near the vent. This was correctly described by Dr. Reinhardt, but overlooked by later authors.

In a recent note in the *Naturalist* on Dr. Charles Wilson Greene's studies of the California toadfish, or "midshipman" (*Porichthys notatus*), the writer, by a slip of the pen, made a statement just the opposite of the truth.

The fish showed no luminosity, save when excited by electricity or by ammonia. In an aquarium made alkaline by ammonia water all the spots and organs of the lateral line gave out a brilliant glow, fading away in about twenty minutes. Parts of the fish, after death, were luminous under ammonia. A similar effect was shown by severe electric stimulations, but a mild current produced no effect.

D. S. J.

Compensatory Movements of the Eyes in Fishes.—It is well known that when a dogfish is rotated on its long axis its eyes are

turned so as to compensate in a measure for the abnormal position in which the fish is placed. Lee showed that these compensatory movements may be called forth by stimulating the sense organs of the semicircular canals in a quiet dogfish resting in a normal position, and he therefore believed that the normal compensatory movements of the eye were reflexes produced by a stimulation of the organs of the semicircular canals. E. P. Lyon[1] has made the interesting discovery that certain eye movements can be produced without the intervention of the semicircular canals. If the tail of a dogfish is turned to one side, the eye of the same side is directed forward, that of the opposite side, backward. As this experiment succeeds after the eighth nerves are cut, it follows that this reflex is not to be regarded as originating in the ear. Moreover, when the spinal cord is divided well forward in the body, the reflex ceases, and the author, therefore, rightly concludes that the sensory disturbances, which give rise to the reflex, are located in the posterior part of the trunk and make their way forward through the cord. The author finally calls attention to the uncertainty of compensatory movements of the eye as evidence of stimulation of the organs in the semicircular canals.

P.

Development of Lepidosiren. — The development of this rare and interesting fish is being worked out by J. Graham Kerr,[2] whose first paper on the subject gives an account of the way in which eggs may be obtained and the external features of their development. The eggs are laid in underground burrows in swamps. The fertilized egg as taken from the nest is enclosed in a thin, horny capsule, round which is occasionally a jelly-like envelope. Segmentation is complete and unequal, as in Amia. The gastrula closely resembles that of Petromyzon. The medullary folds are low, and the neural axis arises mainly as a solid down-growth. There is no neurenteric canal. Four external gills are developed upon branchial arches, I, II, III, and IV. Auditory and nasal sacs and stomodæum are formed by secondary excavation of originally solid rudiments. The young fish, which at hatching is tadpole-like, remains two weeks without developing pigment, after which the retinal pigment begins

[1] Lyon, E. P. Compensatory Motions in Fishes, *Amer. Journ. of Phys.*, vol. iv (1900), pp. 77–82.

[2] Kerr, J. Graham. The External Features in the Development of Lepidosiren paradoxa Fitz, *Phil. Trans. Roy. Soc. London*, Ser. B, vol. cxcii (1900), pp. 299–330, Pls. VIII–XII.

to appear. The fore and hind limbs suffer rotation, so that the resultant upper surface of either is homologous with the lower surface of the other, as in Ceratodus. Pulmonary breathing begins before the external gills show signs of degeneration. About six weeks after hatching, the external gills are lost. The young Lepidosiren is remarkably newt-like in its general appearance and uses its hind limbs in clambering about the vegetation. It also has some powers of change of color by the action of its chromatophores. P.

Multiplication of Nuclei in Transversely Striped Muscle Fibres of Vertebrates.[1] — Godelewski's work, of which he gives a preliminary account, was carried on at the Anatomical Institute of the Jagellonian University at Krakow. The material was from late embryos and recently born young of the guinea pig and mouse, and from larvæ of Salamandra. To avoid undue contraction of the muscles the whole extremity was employed; it was fixed in Perenyi's fluid or in concentrated sublimate solution plus 2 per cent acetic acid. The sections, 5 μ thick, were stained either in thionin or in Heidenhain's iron-hæmatoxylin, followed by Bordeaux R or eosin.

In the quiescent nuclei of embryonic or larval muscle cells the chromatin constitutes a thin layer at the periphery of the nucleus, which contrasts sharply by its blue color with the single brilliant red nucleolus. That the nuclei are highly elastic is shown by the flattened forms they assume in muscles that have strongly contracted owing to their being cut away from their attachments to bone before fixing.

Nuclear reproduction takes place both by the mitotic and by the amitotic process. The author has observed all stages of mitosis in muscle fibres that were already distinctly striped, not only in the deep nuclei, but also in those that had already attained a peripheral position. The approaching division is indicated by an increase both in the size of the nucleus and in the distinctness of the chromatic network. The nucleolus disappears. The fibrillæ next the nucleus separate a little from each other, and a clear fluid plasma accumulates around the nucleus. If this is a marginal nucleus, it protrudes with its enveloping plasma beyond the surface of the fibre.

Special attention was directed to the question of the presence of centrosomes. Though previous observers have never announced the existence of centrosomes in differentiated transversely striped muscle

[1] Godelewski, E., Jr. Ueber die Vermehrung in den quergestreiften Muskelfasern der Wirbelthiere, *Bull. de l'Acad. des Sciences de Cracovie.* Avril, 1900.

tissue, the author found them in typical form, not only in the monaster stage, but even as early as the spireme stage. In the former the central corpuscle, stained black in iron-hæmatoxylin, was surrounded by a typical polar star. Also in the diaster stage the centrosomes continue to be evident; the axis of the central spindle is at first straight, but later may become bent; the interzonal filaments, with their equatorial thickenings, become pressed together to form the deeply staining "Zwischenkörper," which here, as in other cases, is not dependent on the formation of a cell wall. In the [cup-shaped] depression of the nuclei of the diaster stage a remnant of the centrosome and the achromatic cone fibres is still visible, and after the formation of a nuclear membrane around the two masses of chromatin, establishing the two daughter-nuclei, traces of the "Zwischenkörper" and central spindle are still to be seen.

During karyokinesis the surrounding protoplasm acquires a granular appearance. The granules, which are deeply stained in iron-hæmatoxylin, appear in the monaster stage; in the diaster stage and the following anaphase these increase in number, so that the mitotic figure is surrounded by coarsely granular protoplasm.

In addition to the karyokinetic, there is also an amitotic nuclear division, and while in general it may be said that the latter method replaces the former, the author is unable to say just when the one ceases or the other begins. Both processes are, indeed, to be seen in older embryos at the same time and in the same muscle. The first indication of the non-mitotic division is to be seen in the nucleoli, of which there are at first one or two to each nucleus. The nucleolus elongates, becomes narrower in the middle, at length dumb-bell-shaped, and finally divided; the two nucleoli then move apart. This process may be repeated. The chromatic substance meanwhile becomes collected into lumps of irregular form, which are, however, uniformly distributed through the nucleus.

The actual division of the nucleus may take place in one or the other of two ways: First, by the formation of a thin, flat partition, which is perpendicular to the axis of the elongated nucleus or, often, oblique to it. Sometimes only a single partition is formed, but often the nucleus is divided by such partitions into as many as six, or even more, portions — the new or daughter nuclei; secondly, by the formation of invaginations from [*i.e.*, constrictions of] the periphery of the nucleus this very much elongated body is finally divided into two, or sometimes several, not always equal, parts, each of which contains a single nucleolus or, less often, two. The daughter-nuclei

separate from each other, but occasionally they remain connected by a bridge of substance, and in some cases this is elongated, so that when several daughter-nuclei in succession are thus joined they resemble a rosary.

Both forms of fragmentation may occur side by side in the same muscle, and even in the same nucleus. Besides these nearly transverse divisions, a longitudinal splitting of the nucleus is sometimes met with.

H.

Are the Solpugids Poisonous? — It has long been a disputed question as to whether the arachnids known as Solpugids are poisonous or not. In the regions where they occur they have a very bad reputation; but naturalists who have studied their structure have never found poison glands or ducts. Recently Lönnberg[1] has described his observations on *Galeodes araneoides* in the neighborhood of Baku, on the Caspian. He found that the "falanger," as the Russians call it, did not poison insects and other animals upon which it preyed. In attacking a small scorpion it crushed one of the slender joints of the abdomen and then the segment containing the poison sac. It next attacked the larger abdominal segments, working its jaws into the interior and devouring the flesh. During this whole time the scorpion struggled and fought, moving freely and showing no sign of being poisoned. It could not penetrate the skin of a frog, although it attempted to bite it several times. Finally Lönnberg and a friend both allowed the Galeodes to attempt to bite them; but its jaws were not strong enough to penetrate the thickened skin of the finger tips, while flies which were bitten, but which did not have the nervous system injured, were able to crawl around a long time after being bitten. These facts, together with the absence of openings in the chelæ through which poison could escape, led Lönnberg to the conclusion that Galeodes at least is not venomous. At the time for hibernation it dug into the ground, using the two anterior pairs of legs, but where the earth was harder it used the chelæ to remove small stones and bits of clay.

New Jersey Insects. — Professor J. B. Smith's list of the insects occurring in New Jersey is issued as a Supplement to the *27th Annual Report of the State Board of Agriculture* and may be considered a revised and enlarged edition of the one published in 1890 by the Geological Survey of New Jersey. It makes a volume of more than

[1] *Ofversigt k. Vet. Akad. Forhandl. Stockholm*, Bd. lvi (1900), p. 977.

750 pages, with 328 cuts and two maps; one of the maps shows the locations of the colonies of the San José scale, and the other is the 1896 relief map of the State Geological Survey. The list proper is preceded by short chapters dealing with the development of insects, their injuries, insecticides, and machinery.

According to the summary given on page 701, Professor Smith's first list contained 238 families, 2307 genera, and 6098 species; in the volume under consideration 329 families, 3181 genera, and 8537 species are recorded. The increase in the number of families is apparent rather than real, as it is due to a more minute division than was deemed advisable in the earlier volume. As instances it may be noted that the bees listed in 1890 in two families are now given in fourteen, and the sawflies included in the Tenthredinidæ in 1890 are now divided into ten families.

The list, though a useful and interesting one, would have greater scientific value had Professor Smith followed Dr. Calvert's practice, in the Odonata, of including only those species of which he had seen specimens actually collected in the state, or for which the best authority could be cited. The records, "New Jersey probably," "should occur in New Jersey," "will probably occur in New Jersey," are frequent, and in some instances such statements include the data given for all the species of a family. H.

Mating Instinct in Moths. — A. G. Mayer[1] carried 449 cocoons of *Callosamia promethea* from Cambridge, Mass., to Loggerhead Key, off the Florida coast. When the moths emerged they were many hundred miles south of the southernmost range of this species. Experiments were then made on the way in which the females attract the males. Males do not come to females in hermetically sealed glass boxes, but they do congregate about boxes which do not admit of a sight of the female, but which allow odors from the female to escape to the outer air. Males will seek out such boxes even when the vapor of carbon bisulphide or of ethyl mercaptan is escaping from the box, together with such odorous material as the female may produce. The sense organs of the males stimulated by these substances are the antennæ, for when these organs are covered with shellac, glue, or other impervious materials, the males no longer seek the females. Females thirty to sixty hours old are much more attractive to males than young females five to ten hours old. Virgin

[1] Mayer, A. G. On the Mating Instinct in Moths, *Psyche*, vol. ix (1900). pp. 15–20.

females are somewhat more attractive than are fertilized ones of the same age. If the eyes of a male are covered with Brunswick black so as to prevent sight, the male will still mate in a normal way if placed near a female. If the wings of a female, which are of a reddish-blue, are cut off, and the wings of a male, which are darker, are glued to the stumps of the wings on the female, the female insect can be made to look much like the male, and yet males will mate normally with such individuals. Males provided with female wings apparently suffer no disadvantage in mating with females. These and other similar observations lead the author to conclude that the sexes pay no attention to the appearances of their partners, and that the dark coloration of the male has not been brought about through sexual selection on the part of the female. P.

A New Text-Book on Echinoderms.[1] — It is difficult to characterize this part of *A Treatise on Zoölogy*, edited by Professor E. Ray Lankester. What it contains has already been presented to students in a far better form and free from the insular prejudices which are apparent throughout the work. One might almost imagine from the preface that there was a British natural history of echinoderms, as contrasted with that found in the text-books of Zittel, Claus, Neumayer, Hertwig, Korschelt, Heider, and many others which will naturally suggest themselves to the student of echinoderms.

The great value of a text-book consists in an impartial presentation of well-ascertained facts and not in spreading before the reader the peculiar views held by the authors, especially when they are mere speculations reminding us of the elaborate disquisitions of Haeckel on the imaginary crinoids he so carefully figures and describes in his last memoir on the subject.

It would be difficult to write a general description of the echinoderms more likely to confuse the students than the one given by Mr. Bather in the introductory chapter to this part of Lankester's *Treatise on Zoölogy*. It is noted for dwelling on what is not known and for giving us as little as possible (for a work of such pretension) on the structure and embryology of the groups.

The speculations of Mr. Bather might make an article in a geological magazine, but have no place in a text-book designed for "senior students of zoölogy." With the mass of material available to illus-

[1] *A Treatise on Zoölogy*, edited by E. Ray Lankester; Pt. iii, The Echinoderma, by F. A. Bather, assisted by J. W. Gregory and E. S. Goodrich. London, 1900. Adam and Charles Black. 8vo, 344 pp., 11 figs.

trate the anatomy and embryology of echinoderms, it is hardly possible to have given less characteristic illustrations of their structure and development than those selected by Mr. Bather in his introductory chapter on the "Echinoderma."

Mr. Bather has a very extensive and accurate knowledge of the crinoids, and he has given an excellent account of the group, but it is entirely out of proportion to the very moderate one given of the holothurians, starfishes, and Echinoidea. One need only compare Zittel's account of the Echinoidea and Crinoidea with those of Mr. Bather and of Mr. Gregory to see how far Mr. Gregory's account of the Echinoidea falls short of Zittel's admirable presentation of the history of the order.

The authors unite the ophiurans with the starfishes; in this they certainly will not receive the assent of writers on echinoderms, nor is their association of the holothurians, starfishes, and Echinoidea as "Eleutherozoa" in contrast to the Pelmatozoa likely to be accepted.

The student of zoölogy is certainly entitled to a better account of the holothurians than that given by Mr. Goodrich. With the superb figures of Semper, Theel, Ludwig, Semon, and many others available, such figures as are given on pages 218, 219, 222, and 223 are hardly creditable in what is intended to be an important text-book.

The figures as a whole vary greatly in quality; many of the outline cuts of the crinoids and the analyses of the plates are coarse. The figures of the few fossil Echini given are poor, and a large number of the illustrations which accompany the starfishes and ophiurans are not even good as diagrammatic sketches.

The palæontology of the echinoderms is not to be compared with that of Zittel and of Neumayer, and the volume bears too plainly the mark of having been written by palæontologists and not by morphologists familiar at first hand with the structure and development of echinoderms.

Notes. — Students of earthworms will be interested in the results of Michaelsen's recent studies of Kinberg's types of Oligochæta (*Ofversigt k. Vet. Akad. Forhandl. Stockholm*, Bd. LVI, 1900). The only species from the United States included is *Pherctima californica*, which is shown to include two species of Amyntas, *A. californica* and *A. indica.*

In the Stockholm Academy's *Proceedings* (Vol. LVII, No. 1, p. 13) Dr. Einar Lönnberg gives an account of the observations of Professor von Grimm and himself on the fauna of the Caspian. Species of

Gobius, Benthrophilus, and Syngnalhus were obtained, together with numerous Crustacea, many Mollusca, a few worms, and some algæ.

A study of the genera Hygroceleuthus and Dolichopus has led Melander and Brues (*Biol. Bull.*, Vol. I, p. 123) to place all flies belonging to the former genus under Dolichopus, though the species thus transferred form a natural group of less than generic value. In their revision of this genus the authors describe thirteen new species.

The structures which have been described by previous writers as the rudimentary dental ridges in embryo birds have been reinvestigated by H. D. Tjeenk Willink (*Tijdschr. d. Ned. Dierk. Ver.* (2), Bd. VI (1900), pp. 243–254, Taf. XI). These structures are easily identifiable in many species of birds, but are too well developed to be called rudimentary. If they are the remains of dental ridges, which the author believes is by no means certain, they have most assuredly assumed secondary functions and contribute materially to the formation of the horny bill. This function in itself is a sufficient explanation of their presence, without assuming that they are the remains of dental ridges.

Vanhöffen (*Zool. Anzeiger*, Bd. XXIII (1900), pp. 277–279) has investigated the finer structure of three genera of deep-sea medusæ, Atolla, Periphylla, and Periphyllopsis, on material all of which was collected from a greater depth than 600 meters. Both Haeckel and Maas believed that the deep-sea medusæ possessed, in addition to statocysts, eyes of a simple type. Vanhöffen finds no evidence of eyes in the material studied by him and believes that Haeckel mistook pigmented entoderm for eyes, and that Maas was in error because of imperfectly preserved specimens.

Bittacomorpha clavipes Fabr., a near relative of the crane flies, is characterized by having enormously swollen metatarsi on all its legs. Brues (*Biol. Bull.*, Vol. I (1900), pp. 155–160) has found that an enlarged tracheal tube occupies almost the entire cavity of the swollen metatarsus. As this insect flies poorly, the author believes that the balloon-like enlargements of its metatarsi enable it to be wafted easily by currents of air. The coloration of these parts gives the animal, when suspended in air, a striking resemblance to drifting thistle seeds.

The third number of Vol. I of the *Biological Bulletin* contains the following papers: "The Early Cleavage and Formation of the Mesoderm of Serpulorbis squamigerus Carpenter," by S. J. Holmes; "New

Species of Hygroceleuthus and Dolichopus," with remarks on Hygroceleuthus by A. L. Melander and C. T. Brues; "On the Origin of the Sperm Blastophore of Some Aquatic Oligochæta," by S. Hatai; "Peculiar Tracheal Dilatations in Bittacomorpha clavipes Fabr.," by C. T. Brues; and "Lampreys in Captivity," by A. M. Reese.

BOTANY.

Alternation of Generations in Algæ.[1] — The author has made a careful study of the European forms of the Cutleriaceæ, a small but interesting group of algæ, and the results are given in this paper of one hundred pages. Two genera have been known in European waters, Zanardinia and Cutleria, the former represented by a single species, *Z. collaris*, the latter by two, *C. multifida* and *C. adspersa.* Each is represented by a sexual and an asexual form, in Zanardinia indistinguishable in habit, but in Cutleria so different that the asexual form was long known as a separate genus, Aglaozonia.

The paper begins with a thorough résumé of the previous investigations by Thuret, Reinke, Falkenberg, Janczewski, Kuckuck, and Church, which showed Aglaozonia to be included in the Cutleria cycle of development, assigning to *C. multifida*, *A. parvula*, and to *C. adspersa*, *A. chilosa*. The author has discovered a new form, *A. melanoidea*, occurring in the Mediterranean and on the Atlantic coast of Morocco, thus giving three sexual to two asexual forms. Though absolute proof has not been obtained, the author seems justified in regarding the new form as connected with *C. adspersa*, the sexual form corresponding to *A. chilosa* being yet to be discovered. As the asexual form of *C. multifida* has a farther range northward than the sexual form, it is not improbable that the sexual form of *A. chilosa* may be some little known tropical or subtropical species.

In studying the fertilization and development of Cutleria we find a curious complexity. The sexual form is diœcious; in many localities only the female plant is known, propagating freely by parthenogenesis; in some localities male plants are extremely rare; in others they occur in equal numbers with the female, or are even twice as common; but in only one place have cultures shown fecundation of the oöspore. In the locality where the male plant is most abundant

[1] Sauvageau, Camille. Les Cutlériacées et leur alternance de Générations, *Ann. Sci. Nat.*, Ser. 8, Botany, vol. x, pp. 265–362.

no trace of fertilization, or even of attraction between the anthero-zoids and spores, was found, but parthenogenetic growths were abundant. These growths were of two distinct types, both of which were found, only more fully developed, in plants growing in the sea, the two forms there growing intermingled, though not so in cultures. These forms the author designates, from their respective discoverers, as "forme thuretienne" and "forme falkenbergienne," the former producing first a "support," the summit of which is then transformed into a Cutleria frond, the latter a stout cellular cylinder, here called "colonnette," from the base of which grows out an Aglaozonia frond. It would seem that either of these forms may be produced by either Aglaozonia or Cutleria spores, in the latter case by either fertilized or unfertilized spores, so that, instead of a definite alternation of generations, as in ferns and mosses, either the sexual or the asexual form may reproduce itself for an indefinite number of generations, changing to the other under conditions unknown to us.

The "colonnette" is a peculiar development; the author regards it as an atavistic proembryo, representing what was a normal state in the remote history of the type, but is now only a survival, of no use to the individual. These three forms now found in the same species give the latter a wide range of affinities among the brown algæ, indicated by the author as follows: Cutleria, thallus with Ectocarpus, Tilopteris, Carpomitra; reproduction with Tilopteris, Sphacelaria. "Colonnette," thallus with Myriotrichia, Litosiphon; reproduction unknown. Aglaozonia, thallus with Battersia, Sphacelaria, Zonaria, Padina, Dictyota; reproduction with Zonaria, Laminaria. It is this wide range of affinities that makes the study of this little group of so much interest.

The paper is abundantly illustrated from excellent drawings by the author.

F. S. Collins.

Micro-Organisms and Fermentation.[1] — The translation of the third edition of Dr. Jörgensen's well-known work on the subject, in which his word is one of authority, is doubtless a good service for many English-speaking readers. The general subject of fermentation is here so construed as to exclude decomposition changes; the chief phases treated dealing with those activities producing characteristically acetic, lactic, and butyric acids, slime, and alcohol. The

[1] Jörgensen, A. *Micro-Organisms and Fermentation.* Third edition, translated by Alex. K. Miller and A. E. Tennholm. London, Macmillan & Co., 1900. 318 pp., 83 figs.

organisms producing these changes, bacteria, mould fungi, and yeasts, are discussed, chiefly from the standpoint of their morphology and physiology. The most important alcohol-producing organisms are treated in some detail. Here, as throughout the book, the work of Hansen is cited at great length.

Since the work is intended for the brewer and the distiller as well as for the student of the purely scientific side of the subject, much of brewery and distillery technique finds place. As the standpoint of the author is decidedly that of the morphologist, the chemical side of fermentation is disposed of in the briefest manner. On the whole, the book gives a very useful account of the subject as seen from the standpoint of an enthusiastic disciple of Hansen. A fairly complete bibliography of the subject unfortunately closes the book. It is difficult to explain why a work of this scope, intended for frequent reference, should utterly lack an index, but such is the case.

Notes. — Professor Rowlee begins the publication of a series of notes on North American willows in the May number of the *Bulletin of the Torrey Club*, the first part dealing with the Longifoliæ, of which twelve species are recognized, three of them, as well as several varieties, being considered new to science. Gratification is expressed at the necessity that has been found of restoring all of Nuttall's species.

The taxonomic value of the staminate flowers of some species of Quercus is shown by Professor Rowlee and Miss Nichols in the *Botanical Gazette* for May.

The Lycopodiaceæ of the United States are found in review by Lloyd and Underwood in the *Bulletin of the Torrey Club* for April.

Dr. Spegazzini, in the March number of the *Anales de la Sociedad Científica Argentina*, gives some interesting notes on the irritability of the stamens of certain cacti, the extra floral nectar glands of *Opuntia monacantha*, and the narcotic properties of the floral nectar of *Echinocactus gibbosus*.

Professor Nelson's active study of the Wyoming flora leads to the revision of the cormose-rooted Rocky Mountain claytonias in the *Bulletin of the Torrey Botanical Club* for May, in which he further publishes a considerable number of new species of various groups.

In No. 5 of the *Contributions from the New York Botanical Garden* Dr. Rydberg begins a series of studies on the Rocky Mountain flora, the first number of which deals with certain groups of Senecio.

An annotated catalogue of the ferns and flowering plants of Oklahoma, by Professor Bogue, constitutes *Bulletin No. 45* of the Oklahoma Agricultural Experiment Station.

An interesting series of plant-formation figures is being published in the current numbers of the *Revue Générale de Botanique*, in illustration of a paper by Boergesen and Paulsen on the vegetation of the Danish West Indies.

The flora of the Azores, which was summarized in the *Eighth Report of the Missouri Botanical Garden*, receives several important additions in a paper by Gandoger, published in the *Bulletin de la Société Botanique de France* for February.

PALÆONTOLOGY.

Zittel's Text-Book.[1] — The appearance of von Zittel's *Grundzüge der Palaeontologie* in 1895 was generally welcomed as being a most convenient and well-executed outline of the elements of the science. No English translation of any similar foreign book on the general subject had heretofore been published, and the excellence of this work and the fame of its distinguished author seemed to demand its reproduction into English.

Dr. Charles R. Eastman undertook the translation and editing. As a former pupil of Professor von Zittel, and a palæontologist himself, he was especially well qualified for this task. After consultation with a number of leading educators, and with the consent of the author, it was decided to submit different portions to specialists for independent revision. The plan of the original work has been followed throughout, though the amount of revision really makes it a distinct publication.

The early chapters on the Protozoa and Cœlenterata received very little alteration and stand essentially as in the original. The list of collaborators and the subjects revised by them are as follows: Wachsmuth, the Crinoidea and Blastoidea; Sladen, Asteroidea and Echinozoa; Hinde, Vermes; Ulrich, Bryozoa and Ostracoda; Schuchert, Brachiopoda; Dall, Pelecypoda; Pilsbry, Gastropoda; Hyatt, Cephalopoda; Beecher, Trilobita; Clarke and Kingsley, the Eucrustacea

[1] Zittel, Karl A. von. *Text-Book of Palæontology*. Translated and edited by Charles R. Eastman. London, Macmillan & Co., 1900. Vol. i, x + 706 pp., 1476 woodcuts.

and Acerata; Scudder, the Insecta. A few chapters, notably those on the Molluscoidea, Mollusca, and Trilobita, are entirely rewritten.

Science text-books are proverbially behind the advances of the sciences they represent. In general this conservatism is not without compensation, since no single author of a comprehensive treatise can judge of the value of new discoveries or adopt innovations until they have stood the test of time and become incorporated into the standard body of scientific literature. Much of this danger has been obviated by the coöperation of men of recognized authority in special branches and by their restraint in following along prescribed lines.

The result of this coöperation, as in the present volume, is a composite work. Instead of a compilation from various authorities, each chapter bears its own authority, and as such the book will have a standing and usefulness among advanced students it would not otherwise attain.

C. E. B.

NEWS.

THE entomological collections of the late Professor J. A. Lintner are to be given to Cornell University by his widow.

The French Association for the Advancement of Science meets at Paris, August 2 to 9.

The International Botanical Congress will meet in Paris, October 1 to 10. The International Geological Congress meets at the same place August 16 to 28.

Fellowships for the college year 1900 to 1901 have been awarded as follows:

Johns Hopkins University: Lawrence Edmonds Griffin (Ph.B., Hamlin University), Adam Bruce fellow in biology.

University of Pennsylvania: J. R. Nurlin and Miss R. A. Vivian, zoölogy; Miss C. B. Thompson, biology.

Tufts College: R. J. Seymour (B.S., Ohio State University), biology.

Harvard University: W. A. Willard, zoölogy.

Appointments: Miss Cora J. Beckwith, of Ann Arbor, assistant instructor in zoölogy at Vassar College. — W. Bergt, professor extraordinarius of geology in the Dresden Technical School. — Dr. A. N. Berlese, of Bologna, assistant professor of botany in the University of Sassari, Sardinia. — Dr. W. Busse, docent for bacteriology in the University of Berlin. — F. Cavara, professor of botany and director of the botanical gardens at Cagliari, Sardinia. — Mr. Cecil B. Crampton, of Manchester, assistant geologist on the Scottish Geological Survey. — Dr. C. Eckstein, professor of zoölogy in the Forestry School at Eberswald, Germany. — Dr. A. Fritsch, of Vienna, professor extraordinarius of botany at the University of Gratz. — Dr. Ernst Göppert, professor extraordinarius of anatomy in the University of Heidelberg. — Dr. L. E. Griffin, instructor in biology in the Women's College of the Western Reserve University. — Dr. Georg Gürich, professor of geology and mineralogy at Breslau. — W. L. Jepson, assistant professor of botany in the University of California. — Hermann J. Kolbe, director of the zoölogical collection at Berlin, titular

professor. — Dr. Küster, of Munich, docent for botany in the University of Halle. — Dr. J. Marquart, of Tübingen, assistant in the Leiden Ethnographical Museum. — Dr. O. Mattivolo, of Florence, professor of botany in the University of Turin. — Dr. Max Meyer, of Worcester, professor of psychology in the University of Missouri. — Dr. V. Schmidt, of Dorpat, privat docent for histology and embryology at the University of St. Petersburg. — Dr. Schmeisser, of Clausthal, director of the Geological Institute of the School of Mines in Berlin. — James M. Tuomney, of Arizona, assistant professor of forestry at Yale University.

Deaths : Adrien Franchet, botanist, in Paris, aged 66. — Dr. O. Hoffmann, lepidopterologist, at Regensburg, February 22, aged 64. — Dr. H. Kiärskow, editor of the *Botanisk Tidsskrift*, Copenhagen, March 18, aged 64. — Miss Mary H. Kingsley, the well-known African explorer, at Simon's Bay, South Africa, in June. — Dr. E. J. Lowe, a British naturalist, at Chepstow, March 10. — Carl Meinshausen, of the botanical museum of the Academy of Sciences at St. Petersburg. — A. Pellerin, director of the botanical gardens at Nantes, France. — Mr. James Thompson, of Glasgow, a geologist, aged 77. — Professor W. Waagen, professor of palæontology in the University of Vienna, and formerly of the Indian Geological Survey, in Vienna, March 24, aged 59. — Dr. Hugo Zukal, professor extraordinary of botany in the Agricultural School at Vienna, February 15, aged 55.

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(Regular exchanges are not included.)

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DANA, MRS. WILLIAM STAR. How to know the Wild Flowers. New edition with colored plates. New York, Scribners, 1900. 8vo, xxxix + 346 pp., 152 pls., some colored. $2.00.

HARTERT, ERNST. Das Tierreich. 9. Lieferung, Aves, Trochilidæ. Berlin, Friedländer, 1900. ix + 254 pp. 16 marks.

KEELER, HARRIET L. Our Native Trees and how to identify them. New York, Scribners, 1900. 8vo, xxiii + 533 pp., plates and woodcuts. $2.50.

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(*No. 403 was mailed July 25.*)

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CONTENTS

PAGE

I. **Unusual Modes of Breeding and Development among Anura** LILIAN V. SAMPSON 687

II. **On the Intestine of Amia Calva** . . . . WILLIAM A. HILTON 717

III. **Studies in Cranial Variation** . . . . . . Dr. FRANK RUSSELL 737

IV. **Synopses of North-American Invertebrates. XIII. The Actiniaria** . . . . Prof. G. H. PARKER 747

V. **Reviews of Recent Literature:** *General Biology*, Woods Holl Lectures for 1899, Animal and Plant Colors, The Plankton of the Elbe — *Zoölogy*, New Edition of "Wilson's Cell," Intracellular Canals in Ganglion Cells, Vertebrate Anatomy, Elementary Physiology, Formaldehyde, Jordan and Evermann's Fishes, Part IV, The Monascidians of the Bremer Expedition, Relation between Nervous and Glandular Tissue in Ascidians, The Life Cycle of Adelea Ovata, Notes — *Botany*, The Cyclopedia of American Horticulture, Notes — *Geology*, The Yellowstone National Park, Maryland Weather Service, Experimental Geology, Maryland Geological Survey. 759, 761, 767, 770

VI. **Publications Received** 775

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UNUSUAL MODES OF BREEDING AND DEVELOPMENT AMONG ANURA.

LILIAN V. SAMPSON.

It has been my good fortune to obtain from Jamaica a complete series of stages of the development of *Hylodes martinicensis.* The eggs of this frog are deposited on land, and the entire development takes place within the egg-membranes. The stages that correspond to the tadpole of our common frogs are passed through inside the egg-membrane and a fully formed frog emerges at the time of hatching. In connection with the study of the development of Hylodes it has been necessary to collect the descriptions that have been given of exceptional modes of development in the Anura. These accounts are often very fragmentary and widely scattered, so that no small labor has been necessary to bring together the literature of the subject. In the hope that a consecutive and full account of what is known may be of service to others, the following pages have been prepared.

In the groups of fishes and Amphibia the eggs are generally laid in large quantities and are left unprotected, but there are other exceptional modes of propagation in species of

unrelated genera and families. In these cases protection of some sort is generally afforded to the young, or else they have become adapted to an unusual environment. As a result, modifications in the young have been produced, as well as changes in the instincts and even in the anatomy of the parents. Examples among fish are the various cases of nest builders among teleosts; the cases of Bagrus, of the siluroid Chromis, and of other fish that carry the young in the mouth for a longer or shorter period; the case of *Asprœdo lævis*, in which the female carries the eggs and young attached to pedicels on the abdomen; the cases where the male fish is provided with a temporary or permanent pouch for the young, and the cases of partially or entirely viviparous forms among teleosts and selachians. Examples among Amphibia are the viviparous salamander; Plethodon and Autodax, which lay their eggs on land; Desmognathus, Amphiuma, and the Cœcilia, where the eggs are laid in damp places and are surrounded by the parent's body; and a number of Anura, which are the subject of the present paper. For the sake of comparison with what is to follow, the salient points in the development of the common frog may be briefly stated. The eggs are laid in large numbers in water, where the larvæ develop. The newly hatched tadpole adheres at first to a fixed object by means of an adhesive gland, but after a few days it becomes free-swimming. It possesses at first external gills; these are replaced by internal gills, covered by the characteristic operculum; the internal gills are in turn gradually replaced by lungs; in the mean time the hind legs and later the fore legs develop; the tail is absorbed, the shape and position of the mouth are changed, the larval "mouth-parts" are cast off, and the characteristically coiled intestine is shortened. The metamorphosis transforms the aquatic larva into the adult air-breathing form.

This general account is true for all the common frogs and toads of North America and Europe, with the exception of Alytes. The Anura of other regions, especially in the Tropics and the Southern Hemisphere, far from having uniform breeding habits and one mode of development, vary

in many ways. For the sake of completeness, a number of forms will be mentioned that are often referred to in connection with those that have an unusual mode of development; they are forms whose embryology has been but little, if at all, investigated, but whose development takes place under somewhat unusual conditions, so that the embryology is a question of interest.[1]

The eggs of the Japanese frog, *Rhacophorus schlegelii*, are laid from the middle of April to the middle of May in excavations prepared by the female in the muddy banks of paddy-fields, ponds, lakes, etc., 10 to 15 cm. above the water line. As the eggs are laid, they are fertilized, and the gelatinous substance about them is aërated by a kneading motion of the hind legs of the female. Both adults usually escape from the nest by breaking a hole in the side of the bank exposed to the water. The frothy egg-mass hardens on the outside, and within it the tadpoles hatch. The substance about the eggs gradually collapses, and in time flows into the water, carrying with it the tadpoles. The eggs are about 1 mm. in diameter, and devoid of pigment until the tadpole stage, when pigment begins to show in the pectoral region. The segmentation is said to be unequal and holoblastic, though more nearly meroblastic than in any other amphibian egg.[2] The embryo is described as resembling a ganoid embryo, the head being flat upon the yolk, and the body wedged into the large yolk-mass.

It is interesting to note that eggs taken from the nest in the mud invariably die if put into water.

Eggs that are said also to be those of Rhacophorus have been found in various localities in Japan, in a frothy, gelatinous substance on the leaves of trees overhanging the water. How the eggs are deposited is not explained.

Two other frogs, from different parts of the world, leave their spawn on trees, in nests formed of leaves stuck together. One of these, the West-African *Chiromantis guiniensis*, is found

[1] For an index to the forms discussed, with summary of literature referring to each, see Appendix, p. 714. References to reviews are given after special articles.

[2] The segmentation of several other anuran eggs that contain much yolk has not as yet been described.

in Cameruns, Victoria; the other, *Phyllomedusa iheringii*, in the province of Rio Grande, Brazil. In both cases hatched tadpoles have been seen, moving with considerable freedom, in the frothy mass in which the eggs are laid. The nest of the Phyllomedusa has an inferior opening over the water. It is believed that the tadpoles of Chiromantis are washed off the leaves by rain. Tadpoles, hatched in confinement, at first swam in the gelatinous substance which liquefied about them, and being transferred to water, they lived and developed. The account of Chiromantis opens with an exclamation on the remarkable character of the metamorphosis of the frog, and yet the tadpoles are described as having a "rudder-tail, a clump of gills, etc., just like an ordinary tadpole," and they "developed (in water) in the usual way."

The little *Phyllomedusa hypochondrialis*, in Paraguay, selects for the deposition of its eggs a single leaf on a plant near a pool, or over it, not more than two feet above the water. The female carries the male, until a suitable leaf is found; then both frogs hold the tip of the leaf together with their hind legs, and in the funnel thus formed the eggs are deposited, the frogs moving up the leaf as the bottom is filled. One pair of frogs may make two nests with about 100 eggs in each. The eggs contain much yolk and measure 2 mm. in diameter. If put into water, the eggs die, but develop if they are simply kept moist. The tadpoles hatch and escape from the leaf into the water after six days; if the nest has not been directly over the pool, the tadpoles may move (assisted by a jumping motion) several inches along the ground during a shower.

Segmentation is holoblastic, but not very regular; the blastopore closes and a new anus is formed. The embryo at first lies flat upon the yolk, but before the yolk is absorbed the embryo is modeled high up upon it, and the head and tail are entirely separate from it. The yolk is covered by a plexus of vitelline veins.

Three visceral pouches, the 1st, 2d, and 3d branchial, are formed, and external gills appear first on the 1st branchial arch and later on the 2d. The first pair grow rapidly and soon become very long; branched filaments; the second pair

never develop to the same extent. No adhesive gland is formed. When the external gills are developed the tail has grown to a large size and has so ample a blood supply from the dorsal aorta and cutaneous veins that it is supposed to be an important organ of respiration. After hatching, the tip of the tail often vibrates rapidly, perhaps to insure the flow of a constant stream of water over the tail.

Before hatching, the operculum grows back from the hyoid arch, and has a median spiraculum; the external gills are rapidly absorbed, and internal gills are developed. The stomodæum breaks through, at the last stage in the egg, and the tadpole hatches as a free-swimming, transparent larva, with prominent eyes, and with no longer any trace of yolk. The lungs are present. On the day after hatching, pigment appears in the larva.

Five weeks later the hind legs begin to develop, and the tail is absorbed very rapidly, until only a little of it remains. After the legs are formed the frog leaves the water, and the final absorption of the tail takes place on land.[1]

The eggs of *Hyla nebulosa*, found in Rio de Janeiro, hatch in a frothy mass in the sheath of withered banana leaves, but not near a pool. Unlike the tadpoles of Chiromantis, which probably reach the water in the natural course of events, the tadpoles of *Hyla nebulosa* invariably die if they are transferred to water.

The tadpoles of *Cystignathus* (*Paludicola*) *gracilis* in Brazil, and of a frog believed to be *Rhacophorus eques* in Ceylon, are said to undergo part, at least, of their development out of water. The eggs have been found in frothy masses on land, those of Cystignathus usually in the grass in the neighborhood of pools. The adult Cystignathus, and on one occasion two young, were found under decaying trunks of trees, near dried ponds; the larger of the two young possessed the vestige of a tail. The naturalist d'Orbigny found the same species in the Argentine Republic, where it occurs under pieces of wood, near the borders of lakes that are common in the sandy soil. The tadpoles of Rhacophorus were observed superficially and are said to resemble those of the ordinary frog.

[1] For further details, see Budgett ('99).

The adult of the Brazilian frog, *Cystignathus mystaceus*, in the province of Rio Grande do Sul, never goes to water, even to spawn. In the breeding season it prepares a hole under a stone or decayed wood, near the edge of a pool, but above the water line; here the eggs are deposited in comparatively small numbers. The frothy substance about them probably serves as food for the tadpoles, since it diminishes in quantity as they grow. In a dry season the tadpoles may attain great size in the nest, but ordinarily they are washed into the pool, when, after a rain, it overflows. They probably do not go through the entire metamorphosis in the nest, however long they may be detained in it, for tadpoles that had grown there to a considerable size still possessed tails. During development in the nest, external gills were observed; the tail was thought to be not so powerful as that of *Rana esculenta*, and is at first light in color, like the egg, but later becomes pigmented dorsally. Another Brazilian nest builder is *Hyla faber*, which is common in Rio de Janeiro, especially in the mountain regions. The female constructs for the eggs a shallow vessel of mud, about four inches high and a foot in diameter. The nest is carefully built on the bottom of a pool, with its edge projecting above the water. Similar nests have been found in Rio Grande do Sul,[1] and there it has been observed that, if the pool dries, the tadpoles in their little lagoons perish, while the young of *Cystignathus mystaceus* survive, huddled together in the frothy substance in their nest in the bank. The eggs of *Cystignathus typhonius*, a frog common in Porto Rico, have been found under conditions similar to those described in the case of *C. mystaceus*. The tadpoles swam when put into water. The appearance of the hind legs and of the fore legs and the disappearance of the tail were observed.

In Ceylon, a green frothy spawn, about the size of a crow's egg, has been found sticking to the walls of cisterns, to perpendicular rocks of quarries over water, and to the damp

[1] It was formerly supposed by the observer in Rio Grande do Sul that such nests were constructed by *Cystignathus ocellatus*, but there is good reason to suppose that *Hyla faber* is the artisan. In Rio de Janeiro this frog has been observed in the very act of building, which takes place at night.

trunks of trees. After some discussion it has been decided that the spawn is that of *Polypedates maculatus*. A very similar account is given of the blue spawn of *Rana temporalis*, also found in Ceylon. The two descriptions agree so closely that one is led to suspect that the two cases may be one and the same.

The tadpoles of a Brazilian frog, *Hyla* (*Ololygen*) *abbreviata*, have been found in cracks of rocks. The abdomen of the tadpole is flat and serves as a sucker, so that if the perpendicular rock is slightly moist, the tadpole can move rapidly over it without legs. The tail is round, with a fin only at the end; on the ventral side the fin is anteriorly converted into a sole, which probably aids the tadpole in adhering to the rock. The mouth is large and the lips are unusually developed. It is said that the frogs, for a time after metamorphosis, are the color of the rocks. Nothing is recorded as to where the eggs are laid, or how they develop.

The breeding habits of *Pipa americana*,[1] commonly known as the "Surinam toad," have been a subject of observation, still more of discussion, from time to time for more than a century. It has been found in British as well as in Dutch Guiana. The frogs are said to be essentially aquatic, and rarely to leave the water. The eggs are laid in the dry season, when the temperature is exceedingly high. The earlier accounts of spawning are probably based on the observations made by Fermin in Surinam, and published in 1765. He states that the eggs are laid on the sand and are placed by the male on the back of the female; a few minutes after fertilization the female returns with them to the water and swims off. The spawning has recently been described in a different way, as observed on one occasion in the Zoölogical Gardens of London. The animals remained in the water, the oviduct was protruded into a bladder-like pouch, turned up over the back; the male clasped the female, and pushed the eggs out of the bladder, leaving them evenly distributed over the back of the female. It is supposed that the eggs are fertilized in the ovipositor.

[1] A few embryos of Pipa have been in the possession of the Warren Anatomical Museum of the Harvard Medical School.

The dorsal skin of the female thickens about the eggs, until each is enclosed in a dermal "cell" or sac, which is finally covered by an "operculum." Leydig ('**96**) regards the cells as modified glands, and, in corroboration of his view, states that other dermal glands are not found where the cells are formed; he regards the cap of the cell as a secretion of the gland, while formerly it was thought to be a hardened portion of the gelatinous substance around the egg. Whatever the origin of the cells, they are temporary structures which form in response to the stimulus of the eggs; the number of eggs carried by one frog has been variously estimated, and may be more than one hundred.

The eggs develop entirely within the dermal cells, and Fermin has observed that they remain about eighty-two days on the back of the parent. I have found no direct statement as to whether the time of hatching is coincident with the time of leaving the dermal sac, except in Bronn's Thierreich. There it is said that "the hatched young find shelter and nourishment on the parent's back, until after completed metamorphosis," implying that the eggs are hatched some time before the young escape.

The only description of development, based on the observation of many embryos, is one by Jeffries Wyman ('**54**), giving the external characters of three stages.

The limbs develop early; even in the youngest stage, where there were three pairs of external gills, the fore and hind legs were present, in the condition of knobs at the sides of the embryo, the posterior said to be unconnected with the trunk. There were at this stage vitelline vessels, supplying the large yolk-mass. The head was broad and flat, with conspicuous cerebral vesicles and prominent pigmented eyes; the spinal cord was closed.

Later (in the second stage), when the external gills had disappeared, fringed branchial arches were seen by removing the dermal folds which concealed them; the opercular folds opened by a small branchial fissure on each side of the neck, and judging from the figures, did not cover the anterior legs. Rudiments of feet were present on all the extremities. It is

said that the whole yolk-mass was invested with a "tunic" and converted into a spiral intestine, returning to the trunk through the middle of the coil! The nostrils in this stage were seen as round terminal depressions.

In the last stage toes were formed; the skin was furnished with papillæ and protuberances; the intestine had increased in length and was still coiled; the mouth, as in the preceding stages, was placed under the head, at a little distance from the anterior end. Another account states that the horny jaws are not developed. The tail in all embryonic stages was provided with the usual muscles as if for swimming, and was folded against the side of the egg. Wyman shows that, after the supply of gelatinous substance around the egg has been exhausted, the tadpole still continues to increase in size, and he concludes that it must therefore grow at the expense of material from the mother, probably by a secretion of the wall of the cell. In summing up the development of Pipa, Wyman notes that the embryo goes through the usual metamorphosis, having internal and external gills and lungs, also a tail adapted to swimming, although the gills and tail are never used as in the frog. The external branchiæ are lost at a very early period, and the tail is absorbed before the animal escapes from the back of the parent.

The folds of skin covering the internal gills differ from the operculum of the frog in that they open on both sides, and the anterior legs are not covered by them. These relations are similar to those in the larva of Dactylethra, the other representative of the primitive suborder of Aglossa. The presence of external gills has been doubted at various times, but the balance of evidence and the last word on the subject seem to show that they exist for a short period.

An early writer, according to subsequent quotations, affirmed that the tail is devoid of pigment, and believed that it is an embryonic breathing organ. This idea was entertained at a time when the presence of gills was not known; it is not in accordance with Wyman's account, nor with Spallanzani's (**1785**), who concluded, after a careful examination, that the tail does not differ from that of the ordinary tadpole. Furthermore,

Bronn and Balfour state that the tail is absorbed before hatching, and Bronn has implied, as already mentioned, that the hatched young remain for a time on the parent's back. If these statements be true, and if it were also true that the tail assumes the function of respiration, then the animal would be deprived of the embryonic breathing organ some time before it escapes from the cell on the parent's back.

Alytes obstetricans[1] is unique among European frogs in not laying its eggs in water. It occurs in various parts of Europe, such as the Rhine region in Germany, the neighborhood of Marbourg, Paris, and Liège. It has been said that it lives only in regions of hilly ground, where there are clear springs; but Cope (**'85**) records that it is common in dry places near Berlin. The frog digs skillfully, and remains underground by day, but at night it is active in the search for food.

The eggs are laid from March to June (according to locality), in a double string of gelatinous substance. The male loops the eggs about its hind legs in the form of a figure 8, and thus carries them, for about three weeks, when the young have reached a stage of development far beyond that of the typical tadpole at the time of hatching. At the end of the period the male takes the eggs to water, and there the tadpoles leave the egg-membrane, and at once swim about actively. They are said to winter in the tadpole stage, although Claus (**'66**) has affirmed that the metamorphosis is completed in a month. When the tadpole leaves the egg, the external gills are already reduced, and the internal gills are fully developed; the opercular opening is median; the tail is ready for swimming; the lungs are developed; the horny jaws, teeth, and fringed lips are formed (these are said to appear later than in the ordinary frog); the intestine is coiled, and the liver is present; the head kidney is in process of degeneration, and the mesonephros partially developed; the legs are not formed. It has been suggested that the lungs are used before hatching, because air bubbles are given off as soon as the tadpoles reach the water.

[1] A complete account of Vogt's (**'42**) article is not given here. Gasser (**'82**) also describes details not mentioned here, especially in regard to the blastopore, the germ layers, and the development of the pronephros and kidneys.

The egg contains an unusual amount of yolk, and is not pigmented; the segmentation was formerly thought to be meroblastic, but it has recently been described as similar to that of Bombinator. The embryo is said to be ciliated even on the head. Certain peculiarities in the development of the alimentary canal have been recorded. The cavity is at first wide, and in the foregut and hindgut it remains in this condition, the anterior end having the widest lumen; in the middle region the ventral yolk-mass is raised in a ridge, toward the dorsal wall, so that the midgut is, for a time, nearly or entirely barricaded. An early description seems to indicate that the œsophagus is at one time closed by yolk-cells, as in the frog. The liver is said to develop independently, and shortly to acquire an opening into the alimentary canal. It is also said that the vitelline veins are at first not connected with the liver, but pass into it later as the portal vein. The lungs arise as solid masses of cells in the œsophageal region, and subsequently become hollow. An adhesive gland is not mentioned.

Before the gills develop, four gill-slits break through; the external gills are then represented by a single pair, on the third visceral arch; they grow to an unusual length during the life in the egg, and are branched eight or ten times. These delicate plumes are very highly vascular and therefore bright red, and are easily seen through the egg-membrane.

When the tadpoles are about ready to leave the egg, the hatching may be hastened or retarded within the limits of two or three days, by bringing the eggs into water a little before or after the normal time. Tadpoles that were put into water long before the usual time, for example when the external gills were fully developed, fruitlessly turned within the egg-membrane, and finally died.[1] On the other hand, Agassiz tried without success the converse experiment of raising the newly hatched young in air.

Some interesting facts have been discovered in connection

[1] The experiment of first cutting away the egg-membrane and then leaving the tadpoles in water was apparently not tried. Compare experiments on the embryos of the viviparous *Salamandra atra*. Those taken from the uterus, if tended with great care, cast off their gills in water and develop a new set. Chauvin (**'77**).

with the Venezuelan frog *Nototrema oviferum* (*Notodelphys ovipara, Opisthodelphys oviferum*), found at Puerto Cabello. The female is provided with a large dorsal pouch, which opens to the outside at its posterior end. It has been regarded as an invagination of the skin, and unlike the dorsal cells of Pipa it is a permanent organ. Weinland ('54) has described fifteen embryos that were contained in the pouch of one specimen, and had all reached the same point in development. They measured 18 mm. from head to tail, and were folded over a large yolk-mass, that formed about seven-eighths of the egg. The embryos were dark with pigment, but over the yolk there were only scattered pigment cells. The rudiments of body muscles are described as present beneath the skin about the yolk. The head was well defined and of the shape peculiar to the adult, with prominent eyes and semicircular nasal openings. The mouth was ventral near the anterior edge of the head, and measured little less than one-half the width of the head. It is said in the course of the description that the horny jaws were not developed, although at another place in the same account the embryo is paralleled, in respect to the mouth, with the newly hatched Alytes, where the tadpole mouth-parts are present.

In the embryo of Nototrema no adhesive gland was found, and the tongue was not developed. The fore legs measured about 2 mm. and were concealed beneath the operculum; the hind legs were twice as long, the toes were forming. The tail measured 5 mm. in length and 2 mm. in width, and with the hind legs was laid against the side of the egg. The heart was three-chambered, and the aortic arches separated not far from it. The dorsal aorta, posterior vena cava, and portal vein from the gut to the liver were large vessels. The lungs were well developed. The three-lobed liver, the gall bladder, and large pancreas were present, the pancreas surrounded by a coil of gut, leading to the stomach portion. The foregut and also the hindgut were thick-walled and appeared white, while the gut between them was formed of coils packed with yellow yolk. The pronephros had entirely disappeared, and the fat bodies and the kidneys were present.

The most remarkable structures were the gills. Three visceral arches were present, and according to one statement three gill-slits (three slits appear in the figures, but in another part of the description it is said that the first and third arches have each only one free edge — a condition that would admit of only two slits). The gills consisted of a pair of very thin bell-shaped membranes, each gill connected with the gill arches by two filaments, one ending on the first and one on the second arch. This peculiar arrangement led Weinland to the conclusion that the bells represent two gills fused together. He regarded them, in function at least, as external gills. On the free edge of the third arch was found the rudiment of what was supposed to be an internal gill, which suggested that the bell-gills are temporary larval organs. The bell-gills were veined by a capillary network, and the vessels were filled with blood, so that the gills were probably already functioning, although pressed close to the embryo in the egg; it was only after floating them out in water that their windflower shape and large size were discovered. The gill measured across, when expanded, not less than three-quarters of the diameter of the egg. The gill filaments were provided with striped muscle fibres; these muscles, Weinland argued, could not be of use in the egg, but the gills may be retained a short time after hatching, when the muscles might function in water, whether the tadpole remained within the pouch or escaped.

Weinland knew nothing of the subsequent history of the tadpoles, as to when they hatch and whether they ever live in water, either free or within the pouch; Boulenger makes some unqualified statements in regard to these questions.

He has noted the occurrence of eggs in the dorsal pouch of the female of *Nototrema fissipes*; he observed a single specimen, in which there were sixteen ova, measuring each 10 mm. in diameter. "From the size and small number of the ova," he writes, "it may be safely predicted that the young undergo the whole of the metamorphosis, within the pouch, as in *Nototrema oviferum*, which is the nearest ally of *Nototrema fissipes*." Of two species of Nototrema found in Ecuador and Peru, also provided with pouches, Boulenger says in an earlier work (**'82**),

"In *Nototrema testitudineum*, as in *Nototrema oviferum*, the young undergo their complete metamorphosis in the maternal pouch; while in *Nototrema marsupiatum* they leave the pouch in the tadpole state." The tadpoles of *Nototrema marsupiatum*, and those of another species, *Nototrema plumbeum*, are set free in water, according to Werner ('98).

Yet another frog of the tropical Andes, *Amphignathodon güntheri*, is said to have a dorsal pouch, which is probably a receptacle for eggs.

The female of a small Venezuelan species, *Nototrema pygmæum*, bears from four to seven young in a dorsal pouch, which splits open when the development of the tadpoles is complete. The pressure of the active young starts the splitting of the pouch at the slit-shaped posterior opening, and the whole pouch is laid open in the middle line. The pocket is perhaps formed from lateral folds after the eggs are placed on the back, and is possibly not closed again after the young escape, but is formed anew at the next breeding season; or the pouch is perhaps never formed a second time.

Observations on a number of tadpoles of *Rhinoderma darwinii* have disclosed some of the facts of the development of this interesting frog. It was first discovered on the voyage of the *Beagle*, in the shady forest of the province of Valdiera in Chile. It was formerly supposed to be oviparous, but, in reality, the tadpoles develop in an enormously expanded gular pouch, which covers nearly the entire ventral side of the male frog.

One account tells of fifty embryos in the pouches of five adults, and a much later account describes certain features of eleven tadpoles of one pouch. The tadpoles from one adult are not equally developed.

The youngest tadpoles described were thought to be just hatched. They measured 4 mm. to the tail; the alimentary canal was not differentiated, but contained much yolk. In all later specimens the alimentary canal was short, coiled, and of a yellow color, due to the presence of yolk. No external gills were observed, nor horny mouth-parts. Internal gills are not mentioned, although the anterior legs in young stages are concealed beneath a fold of skin (suggesting the operculum).

The hind legs develop before the fore legs and in late stages the feet are webbed. The tail is weak and small, and in the youngest embryos lies along the middle line of the egg-sphere. The oldest tadpoles had lost the tail, but at a period before its absorption both fore and hind legs were present and free.

The adults of *Hyla gœldii* have been found in Rio de Janeiro in water, contained in the central cup of certain Bromeliaceæ, and also on dry bamboo near Bromelia. The dorsal skin of the female is slightly raised around the edge of the back, forming a shallow cup, where the eggs are carried. In one case the dorsal vessel contained twenty-six pale eggs. Judging from the figures, the embryos, in external appearance, resemble to a remarkable degree those of *Hylodes martinicensis*. They are unpigmented and are bent around a large yolk-mass, 4 mm. in diameter. The head, which is large and flat, and the eyes may be seen through the egg-membrane. No traces of gills were discovered. The accounts vary as to the condition of the embryo when hatched. According to Goeldi ('95), frogs that hatched in confinement possessed both pairs of legs and small tails; the young jumped about actively and preferred not to stay in water. No details are recorded, but it is implied that the development is abridged and direct. Werner ('98) affirms that the tadpoles are ready to swim when hatched, and that the mother finds water to deposit them in. According to Fritz Müller's description in a letter to Darwin, the tadpole which he observed did not possess fore legs until two weeks after hatching; he saw no external branchiæ or opening that might lead to internal branchiæ.

Another mode of carrying eggs by the female frog is seen in the case of *Rhacophorus reticulatus* (*Polypedates reticulatus*). A single specimen, which was captured at a high elevation in Ceylon, carried twenty-one ova adhering firmly to the abdomen. It is uncertain whether the frog was caught in water or on land, and nothing has been noted as to the development.

An interesting adaptation in a dry climate is recorded of a species of *Spea* (*hammondii?*) in western North America. The eggs are deposited in rain pools, which collect in the dry arroyas and in the low lands. The tadpoles acquire their legs

very early, and are soon able to escape from the muddy fluid; thus, by accelerated metamorphosis, the chances of succumbing because of drought are lessened.

Lythodites latrans, which lives in fissures of limestone precipices of western Texas, is also supposed to deposit its eggs in pools of rain water.

The eggs of *Phryniscus nigricans*, in Paraguay, are laid singly, in temporary pools in grassy ground. "The eggs and larvæ do not seem to differ in any great degree from those of Rana. There is, however, a very large yolk plug, which remains evident after the closure of the neural groove." The development is very rapid, and, within twenty-four hours after segmentation begins, the tadpoles are hatched and wriggling about. They are probably washed into deeper pools.

Another case of rapid development is that of *Paludicola fuscomaculata*, also found in Paraguay. It spawns in January in shallow pools, and the eggs float on the surface. They measure 1 mm., are unpigmented, and have very little yolk. The tadpoles hatch within eighteen to twenty-four hours after segmentation begins, and hang in the water from the floating froth. "Many of the processes of development are blurred and, as it were, hurried over. The external gills never reach a high state of development."

Eggs which are thought to develop like those of Paludicola are said by the natives of Paraguay to belong to the frog called by them "Po it," more scientifically *Eugystoma ovale*. Eggs and larvæ are found in froth in holes in the ground, beneath fallen tree trunks. The nests "were a most ingenious contrivance for collecting water and keeping the eggs and larvæ at least moist between the storms of the wet season. They were always found within the forest belts which lay on the highest ground." The larvæ "would exist for a very long time in a small quantity of water without increasing in size, but when removed to a tank they grew enormously and very soon left the water."

A curious indifference to water has been observed in the case of *Spea bombifrons*, near Market Lake, in Idaho. The tadpoles, still "in the free-swimming condition," but entirely

air-breathers, were seen quite out of reach of the water, in small spaces which they had cleared in the ground. The legs were full-grown, the tail undiminished, the jaws toothless and cartilaginous and "some quite larval in form."

Two species of Dendrobates resort to a device by which it is supposed that the young are transferred from one pool to another. The accounts are sometimes referred to as if they related to a single species. The species closely resemble each other, except in size; the larger, *Dendrobates trivittatus*,[1] is found in Dutch Guiana, the smaller, *Dendrobates braccatus*,[2] occurs in western Brazil. These frogs and *Phyllobates trinitatus* from Trinidad and Venezuela have the habit of carrying their tadpoles attached to the back, whether by suckers or by a viscid secretion from the parent, or by both, has not been determined. It has been observed in the case of *D. trivittatus* that the frog spawns in water, and that the free-swimming tadpoles attach themselves to the parent. They adhere firmly, since they were not brushed off when the parent was hotly pursued and crawled rapidly through the grass; the frog on this occasion was found far from water, and emerged from the grass and bushes freshly wet with rain.

D. braccatus is found on a table-land where, even in the wet season, the water may dry off in two or three days.

The tadpoles of both species possess the usual larval organs, including the horny mouth-parts. The intestine of the tadpole of *D. trivittatus* is said to be shorter and less coiled than in the ordinary tadpole, and to contain yolk.

In the case of Phyllobates it is the male frog that transports the young, but the sex of the frog is not recorded in either case of Dendrobates. The tadpoles of Phyllobates are ranoid, and the tail is about twice as long as the body; the anus is dextral, and the spiraculum sinistral.

[1] *Dendrobates trivittatus* has been wrongly called by one observer (Wyman, '59) *Hylodes lineatus*.

[2] Smith, in describing *Dendrobates braccatus*, reports that the natives of Brazil brought him from the Santarem forest a similar, though larger, frog and affirmed that, like *Dendrobates braccatus*, it transports its young. This may have been *Dendrobates trivittatus*, which is described by Wyman and others, since the difference between the two species is one of size.

A case which resembles Phyllobates and the like, superficially at least, has been discovered by Brauer ('98) in the Seychelles. *Arthroleptis seychellensis* inhabits a forest about 500 feet above the sea, where the streams are swift and there is no still water. The frogs are found in decayed trunks and among damp leaves on the ground, and on one occasion, late in August, a number of eggs were found under leaves from which the adult had been frightened away. The eggs were not included in a common gelatinous covering; they hatched in a glass, and the tadpoles immediately stuck to the glass by their abdomens. Tadpoles of about the same stage of development were also found adhering to the back and sides of an adult. The tadpoles had prominent eyes, mouth well under the anterior end of the head, short hind legs, fore legs concealed beneath an operculum, rudder tails more than twice as long as the body, and a large amount of yolk bulging out on either side of the body. No opening was found to the operculum, and no internal gills, nor were the rudiments of lungs discovered. The outer layer of epithelial cells on the abdomen was columnar, making the epithelium appreciably thicker there than elsewhere; gland cells were wanting on the abdomen only, though a slimy secretion covered the surface. An adult carrying older tadpoles was found at another time. Gland cells were present on the abdomens of these tadpoles; the anterior legs had come through the skin, the toes were found on all the feet, the length of the tail was not reduced in proportion to the body, and much yolk was still present. Rudiments of lungs were found, and the entodermic epithelium had differentiated from the yolk.

Brauer concludes that the eggs are covered with leaves by the parent (probably the male), that the young, when hatched, place themselves, with the assistance of their tails, on the parent's back, where they adhere partly by suction, partly by aid of the roughness of the parent's skin, and partly by a secretion, largely from the adult. Finally, the tadpoles are not attached to the parent for transportation to water, but undergo a large part of their development on its back.

Hylodes martinicensis has been described as the "coqui"

found on several of the islands of the West Indies. Superficial descriptions of the eggs are recorded by two writers (Bello, '**71**; Peters, '**76**). The eggs were found on damp leaves of plants, and near them was the female, apparently on guard. The frogs hatched in the adult form after fourteen days. The embryo is described as wrapped about the yolk, like a mammal. On the seventh or eighth day both pairs of legs were present, and the tail, eyes, and pulsating blood vessels were observed. On the twelfth the characteristic toes and suckers had appeared. The tail was turned downward, with the broad surface pressed against either the right or left side of the embryo. There was no trace of gills or gill-slits, but the tail was so fully supplied with blood that it was regarded, without doubt, as a breathing organ. On the fourteenth day newly hatched embryos were 5 mm. in length, and the tail, which measured about 1.8 mm., was absorbed during the course of the day.

In 1873 there appeared in several magazines various accounts, by Bavay, of a frog which he called *Hylodes martinicensis.* The accounts differ in some respects from those of the other observers of Hylodes, but are not altogether consistent among themselves, so that Bavay's observations were probably not very accurate. He affirms that in one locality, at least, spawning does not take place during the dry season, or even after lack of rain in the wet season; the eggs are always found in damp places, under stones or with decaying leaves. Instead of fourteen days, he allows only ten or eleven for hatching, and states that the frog goes through the usual metamorphosis within the egg. The eyes, legs, tail, and feet he describes at a period earlier than that in which they were found by the other observers, but in regard to the tail his own accounts vary; he stated at first that it disappeared two days before hatching, but afterwards announced in a published letter that he found a vestige of a tail in tadpoles just hatched, when they were hardened in glycerine. The vitellus, according to his observations, was at first connected with the embryo by a cord, for the embryo on the fourth day moved independently of the yolk-mass, although at the same time both

rotated together in the egg. On the sixth day the yolk was covered with a vascular network, and on the ninth it had been incorporated in the body. On the fourth day, when the embryo was turning actively, the heart was beating, and on either side of it there was a trace of a gill; a vein and artery were seen running parallel in the gill. In the course of the next few days the gills had first increased and become blood-red, then diminished, and on the seventh day only a red spot remained, which disappeared on the ninth. Bavay's observations were made in Guadeloupe, and it is possible that on this island there is a frog differing from *Hylodes martinicensis* in the points indicated by Bavay's description.

A study of two stages of the excretory system of Hylodes led Selenka (**'82**) to the opinion that the embryonic and permanent kidneys develop earlier than in the frog, producing a condition which approaches that of reptiles.

It would be interesting to know something of the development of *Hylella platycephala*, a frog which occurs in southern Mexico. It is said to lay its eggs in the axils of the leaves of Tillandsia, where the frog "undergoes its metamorphosis, high above the ground."[1]

Whether the entire development occurs within the egg-membrane, and whether water continually remains on the plant is not stated.

A short note on a frog, supposed to be *Hylodes lineatus*, records some evidence that its embryos undergo their entire development within the egg-membrane. The eggs have been found in Peru under grass far from water, and the embryo not yet hatched possessed no trace of a tail, but well-developed feet provided with suckers.

The young of *Rana opisthodon* hatch in the adult condition. Eggs were collected in crevices of rocks close to a stream on a peak of one of the Solomon Islands. The eggs measured from 6 to 10 mm. in diameter. In the younger stages the

[1] Andrews (**'92**) reports that the eggs of a tree frog in Jamaica have been found in the water at the bases of the leaves of epiphytic bromelias. They were observed in early stages of development, at the end of May, in the region of Mandeville.

embryo was folded around a large yolk-mass in the same way as *Hylodes martinicensis*. The tail was entirely wanting in the more advanced specimens. No traces of gills were found, but on each side of the body were several transverse folds of skin that were thought to be respiratory organs. The legs were well developed; the anterior were shorter than the posterior. The tip of the upper lip was furnished with a small conical protuberance, which in one case projected through the envelope of the egg, suggesting that its function is to perforate the egg-membrane.

The South African frog *Dactylethra capensis*, like *Pipa americana*, the other representative of the Aglossa, lives entirely in water; the tadpoles of the two forms agree in having the fore limbs free from the operculum and in having two spiraculæ.

Leslie (**'90**) writes of Dactylethra (called by him Xenopus): "Its habits are essentially aquatic, the animal never leaving the water except in search of places where food or shelter is better supplied. Unlike other frogs, it feeds in the water, on insects, small fishes, or even young and larvæ of its own kind, and is apparently unable to feed out of that element. The mode of eating is by forcing the prey into the mouth by means of the hands, which act as a pair of claspers; the deglutition always takes place under water. Locomotion on land is by difficult and awkward crawling and leaping. But Xenopus is a most admirable swimmer, and remarkable for the manner in which it remains poised for a long time immediately under the surface of the water, with the nostrils only exposed. The whole structure of the animal denotes its thoroughly aquatic habits — the broadly webbed toes, the smooth, slimy skin with its symmetrically disposed muciferous tubules; there are no eyelids proper, but merely the transparent nictitating membrane, moving up and down; and the nostrils have a disk-like internal valve. When at rest, Xenopus never assumes a sitting posture like other frogs and toads, and the back never appears humped."

The eggs (measuring about one-sixteenth inch in diameter) are laid singly and attached to water-plants or stones, each

surrounded by a mucilaginous covering. They are at first very slightly pigmented. Tadpoles in the Zoölogical Gardens in London hatched in about two days; the head of the newly hatched tadpole is broad and flat; the fin is developed on the tail to the posterior end, and there is no chimæroid lash as Parker ('**77**), and subsequently the text-books, have figured; the intestine is coiled as usual. The tadpoles in confinement had access to vegetable food, but subsisted entirely on an animal diet. A single ventral adhesive gland persists for a long time and at an early period occupies the whole ventral surface of the head. The buccal cavity is open to the exterior the day after hatching. No jaws or beak develop. A few days after hatching a pair of tentacles develop on either side at the angles of the jaw; one of them may become bifurcated and each is provided with two channels through which the blood streams. External gills are not wholly wanting (as was formerly thought), for two days after hatching, when the operculum is commencing as a free fold, there are vascular lamellæ on the first three branchial arches. The gill-slits open later than the mouth; the hyoid cleft opens last by a tube into the first branchial cleft, a long way from its opening to the exterior. At the same time that the gill-slits open, a tufted filtering apparatus is developed from the branchial arches; this becomes vascular and must, it is thought, be respiratory, as no internal gills develop. The opercular folds do not cover the arms, but open by a slit on each side, anterior to the arm. The spiraculæ persist for a long time. The pronephros develops as in the ordinary frog. The vascular system develops as described by Maurer for *Rana esculenta*.

It is evident from the foregoing review that many points in the embryology of the Anura remain to be investigated; it is not, however, surprising that the work has been left undone, when we consider the geographical, the climatic, and other difficulties attendant upon making observations and collecting material.

Germantown, Penn., 1900.

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'98 WERNER, FRZ. Ueber Brutpflege bei Amphibien. *Verh. d. k. k. zool.-bot. Ges. Wien.* Bd. xlviii, Heft 1, p. 11.

'77 WILDER, B. G. Note on Embryo of Pipa americana. *Am. Nat.* Vol. xi, p. 491.

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'54a —— WYMAN, JEFFRIES. On the Development of Pipa americana. *Proc. Boston Soc. Nat. Hist.* Vol. v, p. 13.

'54b —— Observations on the Surinam Toad, Pipa americana. *Amer. Journ. of Sci.* Vol. xvii, p. 369.

'57 —— On the Exhibit from Surinam, Hylodes lineatus. *Proc. Boston Soc. Nat. Hist.* Vol. vi, p. 269.

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'62 —— Dactylethra. *Proc. Boston Soc. Nat. Hist.* Vol. ix, p. 155.

APPENDIX I.

Since this paper went to press, there have appeared the following notes on Nototrema by Brandes, '**99**. "Larven zweier Nototrema-Arten. Demonstration." *Verhandlung der deutschen Zool. Ges., 9. Jahresvers.* Hamburg, p. 288.

The female of *Nototrema marsupiatum* carries a great number of small eggs (200). The full-grown larva has a rudder-tail with a well developed capillary network, hind legs in the condition of knobs, horny teeth, and an operculum with a lateral spiraculum. Through the spiraculum project two filaments, which can be traced to the first and second gill arches of the opposite side. The filaments are expanded at their ends into a delicate membrane, spread out under the egg-membrane. The gills are thus reduced to two, both arising from the same side. In the larva examined, the yolk had been entirely absorbed, so that life in the egg-membrane was no longer possible. A larva caught in water resembled a tadpole of the European Pelobates shortly before metamorphosis.

Nototrema oviferum carries only thirty large eggs. The tadpoles observed had well developed hind legs; the tails had entirely degenerated; there was no spiraculum, but through a broad slit in the operculum projected the two bell-gills described by Weinland ('**54a**). Four gill arches were present, and the gill filaments were attached to the first and second arches.

APPENDIX II.

Index to species, with a summary of references to each.

Alytes obstetricans. Europe.
Demours, 1741. Wagler, '33. Vogt, '42. Steenstrup, '46. Claus, '66. De l'Isle, '76. Leydig, '77. Gasser, '82. Hartmann, '96. Wyman, '59. Nature, '77. Bronn, '78. Knauer, '78. Cope, '85. Sarasin, '87. Boulenger, '86a. *Ib.*, '98. Werner, '98. Page **696**.

Amphignathodon guentheri. Tropical Andes.
Cope, '85. Page **700**.

Arthroleptis seychellensis. Seychelles.
Brauer, '98. Page **704**.

Chiromantis guiniensis (*C. refuscens*). West Africa.
Peters, '75. *Ib.*, '76 (plate). Ihering, '86. Nature, '77. Bronn, '78. Cope, '85. Sarasin, '87. Boulenger, '86a. Werner, '98. Page **689**.

Cystignathus gracilis (*Paludicola gracilis*). d'Orbigny, '47. Hensel, '67b. Sarasin, '87. Boulenger, '86a. Brazil, Argentine Republic. Page **691**.

Cystignathus mystaceus. Rio Grande do Sul.
Hensel, '67a. *Ib.*, '67b. Nature, '77. Knauer, '78. Bronn, '78. Sarasin, '87. Boulenger, '86a. Page **692**.

Cystignathus typhonius. Porto Rico.
Peters, '76. Page **692**.

Dactylethra capensis (*Xenopus lævis*). Southern Africa.
Wyman, '62. Gray, '64a. *Ib.*, '64b. Parker, '77. Boulenger, '81. Leslie, '90. Beddard, '94. Page **707**.

Dendrobates braccatus. West Brazil.
Smith, '87. Cope, '87. Boulenger, '88a. *Ib.*, '88c. *Ib.*, '95. (Boulenger refers indiscriminately to Kappler, '85, and to Smith, '87, and Cope, '87, although these authors have described two species, which Cope says differ in size.) Cope, '89. Werner, '98. Page **703**.

Dendrobates trivittatus. Dutch Guiana.
Wyman, '57. *Ib.*, '59 (under the name of *Hylodes lineatus*). Kappler, '85. Boulenger, '88a. *Ib.*, '88c. *Ib.*, '95. Smith, '87 (in which mention is made of a frog from the Santarem forest, which is perhaps *Dendrobates trivittatus*). Werner, '98. Page **703**.

Engystoma ovale. Paraguay.
Budgett, '99. Page **702**.

Hyla abbreviata (*Ololygon abbreviatus*). Rio Grande do Sul.
Hensel, '67a. Knauer, '78. Page **693**.

Hyla faber. Rio de Janeiro. (Early accounts under the name of *Cystignathus ocellatus.* Rio Grande do Sul.)
Hensel, '67a. *Ib.*, '67b. Goeldi, '95. Bronn, '78. Knauer, '78. Boulenger, '86a. Schönichen, '97. Page **692**.

Hyla goeldii. Rio de Janeiro.
Fritz Müller, '79. Goeldi, '95. Boulenger, '95. Werner, '98. Page **701**.

Hyla nebulosa. Rio de Janeiro.
Goeldi, '95. Page **691**.

Hylella platycephala. Southern Mexico.
Cope, '85. Page **706**.

Hylodes lineatus (?). Peru.
Wolterstorff, '90. Page **706**.

Hylodes martinicensis. West Indies.
Steenstrup, '46. Bello, '71. Bavay, '73a to e. Peters, '76. Selenka, '82. Andrews, '92. Nature, '77. Bronn, '78. Cope, '85. Sarasin, '87. Boulenger, '86a. Page **704**.

Lythodites latrans. Western Texas.
Cope, '85. Page **702**.

Nototrema fissipes. Brazil.
Boulenger, '88b. Page **699**.

Nototrema marsupiatum. Ecuador, Peru.
Boulenger, '80. Weinland, '54a. Nature, '77. Cope, '85. Sarasin, '87. Boulenger, '86a. Page **700**.

Nototrema oviferum (*Notodelphys oviferum. Opisthodelphys oviferum*). Venezuela.
Weinland, '54a. *Ib.*, '54b. Berthold, '56. Wyman, '57. *Ib.*, '59. Owen, '66. De l'Isle, '76. Nature, '77. Bronn, '78. Boulenger, '82. Cope, '85. Howes, '88. Sarasin, '87. Boulenger, '86a. Page **698**.

Nototrema plumbeum.
Werner, '98. Page **700**.

Nototrema pygmæum. Puerto Cabella, Venezuela.
Werner, '98. Page **700**.

Nototrema testitudineum. Ecuador. Peru.
Boulenger, '82. Cope, '85. Sarasin, '87. Boulenger, '86a. Page **700**.

Paludicola fuscomaculata. Paraguay.
Budgett, '99. Page **702**.

Phryniscus nigricans. Paraguay.
Budgett, '99. Page **702**.

Phyllobates trinitatus. Trinidad. Venezuela.
Boulenger, '95. Werner, '98. Page **703**.

Phyllomedusa hypochondrialis. Paraguay.
Budgett, '99. Page **690**.

Phyllomedusa iheringii. Rio Grande.
Ihering, '86. Knauer, '78. Howes, '88. Sarasin, '87. Goeldi, '95. Werner, '98. Page **690**.

Pipa americana. British and Dutch Guiana.
Fermin, 1765a. *Ib.*, 1765b. Laurenti, 1768. Göze, 1776. Spallanzani, 1785. Camper, 1788. Wyman, '54a. *Ib.*, '54b. Parker, '77. Wilder, '77. Sclater, '95. Leydig, '96. Bartlett, '96. Duméril et Bibron, '54. Wyman, '57. Peters, '76. Nature, '77. Knauer, '78. Bronn, '78. Boulenger, '86a. Schönichen, '97. Werner, '98. Page **693**.

Polypedates maculatus. Ceylon.
Gunther, '76. Ferguson, '76. Sarasin, '87. Page **693**.

Rana opisthodon. Solomon Islands.
Boulenger, '86b. Sarasin, '87. Boulenger, '86a. Page **706**.

Rana temporalis. Ceylon.
Sarasin, '87. Page **693**.

Rhacophorus eques. Ceylon.
Sarasin, '87. Page **691**.

Rhacophorus reticulatus (*Polypedates reticulatus*). Ceylon.
Günther, '76. Ferguson, '76. Bronn, '78. Boulenger, '86a. Page **701**.

Rhacophorus schlegelii. Japan.
Holland, '89. Ikeda, '97. Werner, '98. Page **689**.

Rhinoderma darwinii. Chile.
Gay, '36. Espada, '72. Spengel, '77. Howes, '88. Bronn, '78. Boulenger, '86a. Plate, '97. Werner, '98. Page **700**.

Spea bombifrons. Idaho.
Cope, '85. Page **702**.

Spea hammondii. Western North America.
Cope, '85. Page **701**.

ON THE INTESTINE OF AMIA CALVA.

WILLIAM A. HILTON.

Although much work has been done upon the morphology and embryology of Amia, but little attention has been given to the microscopic anatomy of the intestine. After an examination of sections of Amia's intestine, and after comparing them with what has been done on the subject, it was found that there were many interesting but rather difficult problems which remained to be solved. In consideration of some of these points a more careful investigation was undertaken.[1]

In order to obtain a clear idea of the form of the mucosal convolutions, specimens were examined which had been injected with and preserved in either formalin or alcohol. For injecting the capillaries the "Berlin blue injection mass" was used. The body was transsected caudad of the vent, and the injection made into the dorsal aorta within the hæmal arch. In making preparations to show cellular structures the usual histological fixers and stains were used; such fixers as Flemming's, Hermann's, Zenker's fluids and mercuric chloride solution ; such stains as safranin, iron-hæmatoxylin and chloral hæmatoxylin, with picro-fuchsin.

The gross structure of Amia's intestine has been carefully described elsewhere (Hopkins, '92), so a simple description is all that is necessary to give here. The stomach lies parallel to the cephalic part of the intestine and joins it at a very acute angle; the pyloric valve marks the junction of the two parts and appears on the exterior as a very deep constriction. Internally, the pyloric valve projects as a tube a short distance into the cavity. The first part of the intestine is quite long and extends in a parallel line for about two-thirds the length of

[1] The work was done in the histological laboratory of Cornell University. I wish especially to thank Professors Wilder, Gage, and Kingsbury for their valuable suggestions relating to the investigation.

the abdominal cavity. After the first turn the intestine is of considerably less diameter than that of the first part. This second part, after quite an acute angle with the first part, ascends parallel with it for from one-third to one-half of its length, and then, after a very sharp turn, descends once more. After a few centimeters of descent the intestine bulges out to a large diameter, indicating the location of the spiral valve; as it approaches the vent, the spiral valve having ended, the intestine once more becomes of small diameter. The spiral valve, which occupies a few centimeters of extent above the end of the rectum, has from four to four and one-half turns (Hopkins, '95).

Before taking up the finer structure of the intestine, the general form and arrangement of the mucosal convolutions will be considered. In this part of the study it was found that the character of the convolutions was much more easily and accurately made out from gross preparations than from sections, for, although serial sections may show much, a clear comprehension of all the complications can be obtained only by examination of the whole ental surface of the intestine. The following description is largely taken from a single specimen, one having been selected in which the most characteristic condition was presented. Upon a superficial examination of the intestine, slightly distended, the whole ental surface appears to be covered with villi thickly and irregularly placed, varying somewhat in height, but less in general shape, at different parts of the intestine. These appearances are to some extent deceptive; the upper part of the intestine is covered with a network of long and short zigzag folds and isolated villi. The folds run in every direction, and their free edges are more or less irregularly but deeply notched or wavy. Some of the projections or villi are perfectly isolated; others, which at first sight seem to be perfectly free, are found on more careful examination to have connection with their neighbors at the bases. There are all gradations, from perfectly isolated villi to irregular, short, zigzag folds. Many folds or nearly perfect villi join each other throughout their whole height; others slightly at their bases. All are of irregular, undulating heights. Many folds are several centimeters in extent, so that a very complicated

appearance is presented. Between and about the network with the few isolated villi, which altogether form a rather loose meshwork, are much lower and much smaller villi or folds. These are not easily seen, because of the overshadowing higher folds and villi, and, in some specimens, seem to be altogether absent. Some of these lower, smaller folds are joined to the higher ones.

In one of the intestines examined there were, in one or two instances, clumps of folds in very close contact, almost cemented together in one mass; in other places the folds in little groups were in close contact when the intestine was not especially distended, but these, unlike the case just cited, could be separated from each other without tearing. In many cases folds are joined together in the form of a small ring or rather large crypt, not completely closed on one side; but in at least one case a complete ring or crypt was formed by the folds. There are comparatively few projections or villi which are completely separated from all about them, although in many cases the place where they unite with others may be of so little extent that it is easily overlooked.

The tendency of the folds, as well as the arrangement of the larger villi, seems to be fully as great toward a transverse as to a longitudinal direction. The higher villi begin at the pylorus with a height of about .8 mm., and at about the central portion or last portion of the first part of the intestine a height of about 3.5 mm. to 3.8 mm. may be reached; after this the folds and villi become gradually shorter caudad.

Nearer the pylorus folds can be more easily made out than a short distance below, because at first the folds are not so deeply indented on the free edges as farther down; they are also more numerous near the pylorus, that is, less split up into villi. With that part of the intestine a little above the first turn, the folds are more of them deeply split, and there are also numerous large villi, such as 3 mm. long by 1.2 mm. broad. The thickness of the folds and villi is about .2 mm., being in shape thin, plate-like, or leaf-like.

Below the first turn the folds are lower and appear a little more evenly placed, forming more of a continuous network of

rather square meshes than was the case cephalad. Their free edges also seem to be less jagged, but, like those cephalad, they have wavy, free edges, and between the higher convolutions there are lower ones somewhat connected with the larger ones or free. There are comparatively few large, free projections or villi in this region.

At the beginning of the second turn the regular network appearance is usually lost, and the projections shorter, more irregular, and more jagged. After the most cephalic face of the spiral valve is passed, there are a few long, straight folds which appear to run in a longitudinal direction when the intestine is cut open lengthwise and slightly distended. Most of the other folds of the spiral valve might almost be considered to be villi, with rather broad bases and sharp tips. Below the spiral valve the convolutions are usually almost all longitudinally disposed; there are quite a number of low projections nearly free from each other, having rounded edges and arranged in parallel lines, almost like villi, but usually joined to each other by their bases.

The above description applies especially to medium-sized or rather large specimens, many points being obscure in smaller individuals, partly because of the smaller size of the convolutions, and partly because of individual variations. Aside from the usual variations which occur in all specimens without any special rule, there is a way in which large specimens differ from small in quite a constant manner; that is, the difference in the height of the convolutions, the larger individuals usually having longer projections than the smaller. This difference is rather a general one with the villi of many mammals and birds.

The muscular coats of the intestine are, as in all vertebrates, an outer longitudinal and an inner circular. The longitudinal coat is rather thin and made up of small, more or less irregular, bundles of plain muscle. The circular layer of muscle is enormously developed and, for most of its extent, seems to be of about the same thickness. There is but scant connective tissue about the bundles which make up the inner coat, while the connective tissue about the smaller bundles of the longitudinal coat is well developed. These muscular coats vary but little

until the most caudal portion of the intestine is reached, and then, gradually, the muscle of the outer coat becomes less prominent, and at the end of the intestine the outside coat is made up of simply a thick band of connective tissue, with a very few small muscle bundles. There are so few of these that it does not seem that they have a very great part to play in the contraction of the intestine. The inner muscular coat undergoes no such decrease in size at the end of the intestine, but it does undergo some change, and at the last of the intestinal canal there is quite a marked decrease in the thickness of the coat, and the muscle fibres are not completely circularly arranged, as in the rest of the intestine; but a rather complex arrangement of the muscle fibres has taken place, which differs much from the perfectly circular layer of fibres in the other places (Fig. 8). Perhaps this complicated arrangement is partly to compensate for the diminished longitudinal coat and also to take on some new functions, such as some of the muscles of the rectum perform in higher animals.

Just entad of the inner muscular coat is a thick layer of connective tissue composed of fibres longitudinally disposed. This band of connective tissue is about as thick as, or somewhat thicker than, the outside muscular coat and very dense. It does not seem to vary throughout the intestine, except at the end, where it gives place to a dense mass of connective tissue and isolated clumps of plain muscle bundles. At this place the mass of muscle and connective tissue extends uniformly from the epithelium to the inner muscular coat. It is about as thick as the two muscular coats together. With this exception the band of connective tissue is uniform throughout the intestine. It might be considered as an outside layer of submucosa, a sort of base upon which all the rest of the submucosa and mucosa rest. A dense connective-tissue band lying directly inside the muscular coats, but not so close to them as in Amia, has been described for several forms, as in the trout and *Tinca vulgaris*; this membrane has been called the *membrana compacta* or *stratum compactum*. Doubtless the connective-tissue layer in Amia is homologous to this *membrana compacta*.

Especially above the spiral valve connective-tissue strands

from the *membrana compacta* extend to the tips of the folds and villi.

In the upper intestine the submucosa is rather thin, and but a scant *muscularis mucosa* exists. In the region of the spiral valve the submucosa above the *stratum compactum* is a little thicker, and a prominent *muscularis mucosa* is present, lying in a rather dense mass. There are in many places rather isolated muscle fibres of the *muscularis mucosa* going up into the villi, and the connective-tissue prolongations so characteristic of the upper intestine are not nearly so marked. The muscle fibres of the villi extend upwards longitudinally, and were, without doubt, derived from the *muscularis mucosa*, as in mammals and birds. At the very end of the intestine, where folds and villi usually cease, there is an abundant *muscularis mucosa*, there being many longitudinal, and possibly a few transverse, muscle fibres and bundles of fibres scattered irregularly through all the dense connective tissue between the epithelium and muscular coats.

In general, the cores of the villi and folds, also all the submucosa above the *stratum compactum*, are composed of rather dense adenoid connective tissue. There are no lymphatic glands or patches of adenoid tissue anywhere in the intestine, but there are in many places areas of diffuse adenoid tissue, especially in the lower part of the intestine.

Before leaving the submucous structures to go on with those of the epithelium, it may be well to speak of the elements composing the spiral valve. Macallum ('86) states that in the spiral axis of Acipenser and Amia there is a large quantity of unstriated muscular fibres, which in Amia is aggregated into a single bundle. In Acipenser he states that there are several bundles arranged irregularly in direction and position, so it is almost impossible to conceive that they represent excessively developed portions of the *muscularis mucosa*. In Amia, although sections at times seem to show nearly a uniform bundle of muscle fibres occupying the central part of the valve, other and most of the sections show clearly numerous more or less closely placed bundles of plain muscle, most of the fibres running transversely, that is, nearly parallel with the free edges

of the valve. Comparatively few run in the other direction. The *muscularis mucosa* at the base of the spiral valve is not especially thickened or diminished; it occupies its usual position on the ental side of the *stratum compactum.* The connective-tissue layer of the *stratum compactum* on each side of a turn of the spiral is seen in section to send upward into the spiral valve a thick portion of connective tissue; on the ental surface of each of these portions is the usual *muscularis mucosa.* These two layers meet in the basal part of the valve to form a sort of arch. Beneath the arch thus formed are muscle fibres composing one large bundle or several small bundles. It may be seen that in this way muscle and connective tissue are considerably mixed up in the basal part of the valve; but farther entad all become arranged once more, the muscle occupying the center of the valve, while on each side of it, between it and the submucosa, is a rather dense band of connective tissue; these bands, however, are not so dense as to prevent muscle fibres from going up into the villi (Fig. 9).

Three conclusions are to be drawn from the above complicated condition. First, the relative position of muscle and connective tissue is somewhat different from that in the intestine in general. Secondly, the core and, in fact, a large part of the spiral valve are made up of muscular tissue. Thirdly, there is more muscle in the spiral valve than the double thickness of the *muscularis mucosa,* and although a small part of the muscle is derived from the *muscularis mucosa,* by far the larger part is not.

The intestinal epithelium of Amia presents a very interesting condition. The cells are exceedingly small, and in most places it is impossible to make out in sections the cell outlines. Macallum ('**86**) describes the epithelium to be composed of short cylinder cells resting on four layers of nuclei. This is often the appearance presented in sections; sometimes there seem to be six or eight layers of nuclei, especially in the upper part of the intestine; possibly, at times, a few of these nuclei may be those of underlying cells. Macallum figures the nuclei in even layers; this is seldom the case, the nuclei seeming to be scattered irregularly through the epithelium. They are

usually somewhat elliptical, but may be irregularly circular. Isolated preparations from the epithelium are of the utmost value in determining the character and relation of cells. For isolating, Ranvier's dissociator of one-third alcohol was found to be especially good. The isolated cells were of the same length as the thickness of the epithelium, as shown in sections, the cell bodies being usually thin or even thread-like, with nuclei at all levels, thus showing with the greatest clearness that, although somewhat modified, the cells form a simple columnar epithelium. There might have been a few interposed cells at the bases of the longer ones, but if so they were not recognized. Usually, beneath the striated border of the cells is a band which takes a darker stain than the rest of the cell body. This was especially true of the epithelium towards the pylorus.

Although essentially similar in all parts of the intestine, the epithelium is especially thicker in the cephalic portion, there being in this first region a more complicated arrangement of nuclei at different levels. From the spiral valve caudad it is somewhat simpler, that is, it is not so thick, and the outlines of the cells are much easier to trace, there being at most but four layers of nuclei. Compared with the height of the epithelium of the lower intestine, there is greater distance from the surface to where the nuclei are located than is the case in the upper intestine. Goblet cells occur throughout the intestine, being more numerous caudad. In depth the thecas of the goblet cells occupy but a small proportion of the thickness of the epithelium or of the lengths of the cells of which they are parts. This is especially true of the upper part of the intestine.

Macallum ('86) describes cilia throughout the intestine of Amia. Comparing Macallum's statements with sections, in many places cilia seemed to be present, but careful examination of fresh specimens did not bear out these observations. In these experiments, as a check, living cilia were obtained from the œsophagus. Hopkins ('93) describes cilia in a very small area just caudad of the spiral valve; this is the only place in the intestine of Amia where true cilia occur; what

appear to be cilia in other parts are simply the striated border of the epithelium. This border is best marked above the spiral valve; it becomes narrower as the caudad end of the intestine is reached.

The blood of the folds and villi in Amia is supplied by a capillary network which resembles the blood supply of the villi in higher forms. Large blood vessels run in the submucosa and send up branches into the folds and villi. With a villus there are usually three main trunks of arterioles going up into a fine capillary network. When the projections join each other, there are numerous small blood vessels which connect, to a greater or less extent, the two almost distinct capillary systems. The blood supply of the more distinct folds is practically the same as that of the villi—a continuous network, usually supplied by about as many main trunks as if a number of villi occupied the same position.

It will be seen from some of the preceding structures described that a very interesting condition exists in the form and structure of the enteric convolutions. The intestine of Amia presents an appearance midway between folds and villi, having some of both structures, the latter, in a way, developed from the former by unequal growth. The villi possess all the characteristic structures of villi of mammals and birds, as do the folds, but falling short of villi simply because of their extent or lack of separation. In some of the higher forms, to a limited extent, signs of a transition from folds to villi are found, as in the double projections which occur occasionally in the small intestines of rabbits.

Villi have been described in a few species of Pices, but their presence is not usual in this class. However, it may be noted that in general the forms in which villi have been described are what are generally regarded as the higher teleosts. As villi are characteristic of the highest vertebrates, such as mammals and birds, it is not difficult to accommodate villi to the highest fishes. But how are we to account for the specialized condition of the intestine of Amia? Simply as follows: Amia is a very ancient form of vertebrate, one that has changed but little from the ancestral type, and, therefore, has had as a

species a long time for specialization, so the intestine has, during at least part of this time, become highly specialized, probably to suit more exactly the character of its food.

Another interesting point about Amia is the fact that in the spiral valve there is more muscular tissue than could have been derived from the *muscularis mucosa.* How did it get there? The answer to this question can be solved definitely only from the standpoint of embryology, but perhaps a suggestion may not be out of place. If the spiral valve was originally, if not in Amia in its progenitors, formed by a twisting of the whole thickness of the intestine, then a folding of the whole wall would, of course, involve the muscular coats as well as the submucosa and mucosa. In such a case muscle would be left in the spiral valve after readjustment of the outside coats once more to their usual appearance. Muscle from the *muscularis mucosa* would also be in the spiral valve, but the greater part would be from the muscular coats, and, because of the thickness of the inner muscular coat, the larger part of the muscle would run transversely, as is actually the case in the spiral valve of the adult.

General Conclusions.

1. The intestinal convolutions are very complex in form and arrangement, being made up of variously shaped folds and free projections or villi.

2. The muscular coats are well developed, an outer longitudinal and inner circular, the latter very thick.

3. A thick connective-tissue band, of uniform nature throughout the intestine, occurs next the inner muscular coat. This band of connective tissue sends up projections of fibres into some folds and villi.

4. A *muscularis mucosa* is present, a few fibres of which are prolonged into the cores of folds and villi.

5. The epithelium is simple, columnar, four to eight layers of nuclei appearing in sections.

6. The epithelium is not ciliated, except for a small area caudad of the spiral valve.

7. The blood supply of the folds and villi is similar to that of the villi of mammals.

8. True villi and partially developed villi occur.

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EXPLANATION OF PLATE I.

Fig. 1. Intestine of medium-sized *Amia calva*; *st.*, stomach; *py.v.*, pyloric valve; 1, first turn of the intestine; 2, second turn of the intestine; *sp.v.*, region of the spiral valve; *r.*, rectum.

Fig. 2. Folds and small villi of intestine near the pylorus; *f.*, fold; *v.*, villus.

Fig. 3. Intestine below first turn showing the ental surface; *f.*, fold; *v.*, villus.

Fig. 4. Last three faces of the spiral valve split lengthwise and distended, showing longitudinal folds on the spiral valve; *f.*, fold; 2, second face of valve; 3, third face of valve; 4, fourth face of valve; *w.*, intestinal wall.

Fig. 5. Folds near the end of intestine.

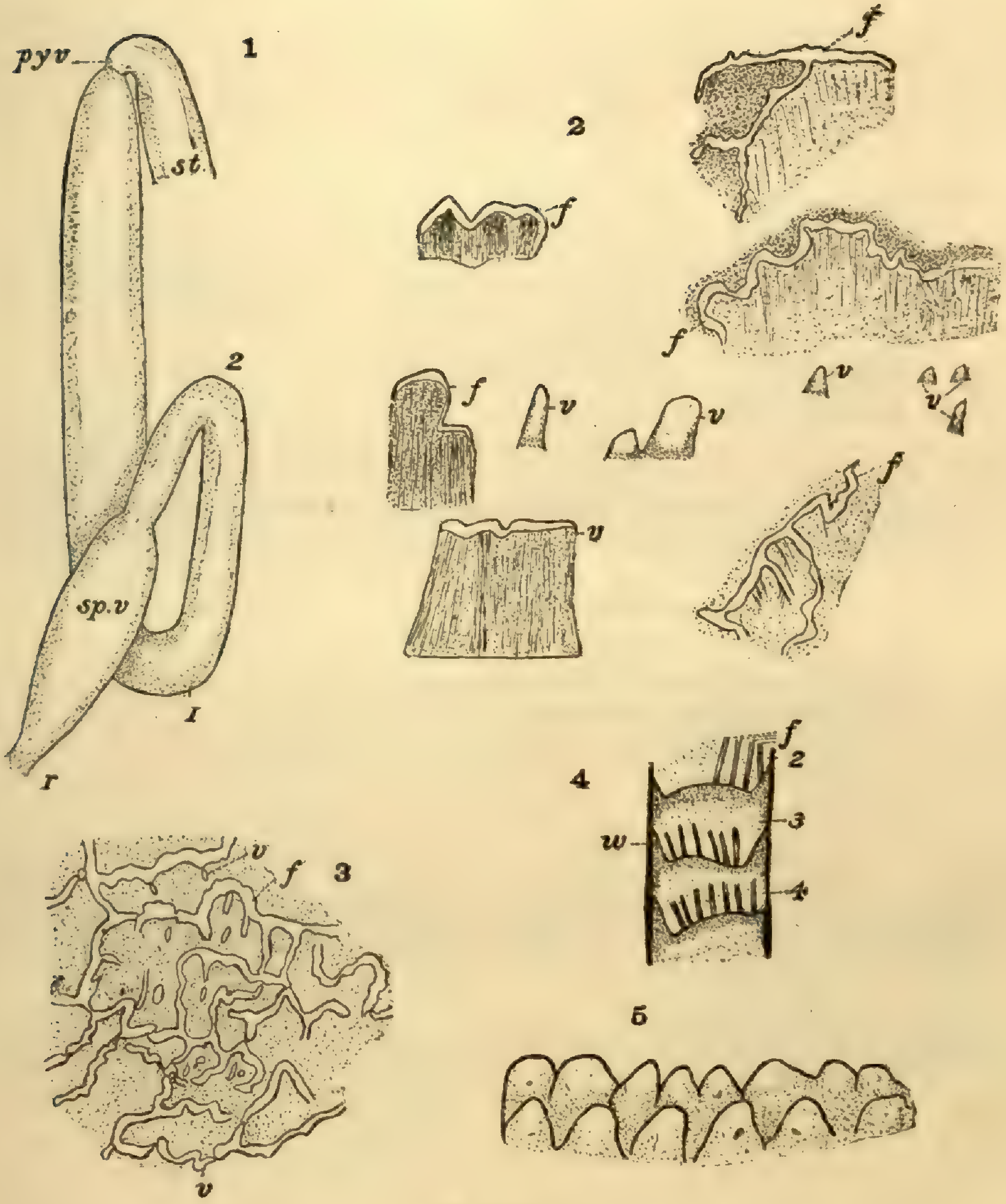

PLATE I.

EXPLANATION OF PLATE II.

E., epithelium; *c.*, cores of folds and villi; *ct.*, connective-tissue prolongations from the *stratum compactum* (*m.*); *im.*, inner muscular coat; *om.*, outer muscular coat; *lm.*, lateral muscular bundles; *tm.*, transverse muscular bundles; *mb.*, muscle bundles; *mm.*, *muscularis mucosa.*

FIG. 6. Sections of the intestine near the pylorus, moderate magnification.

FIG. 7. Section of intestine below spiral valve.

FIG. 8. Section of the end of intestine.

FIG. 9. Transsection of spiral valve, not showing epithelium.

(All figures × 37.)

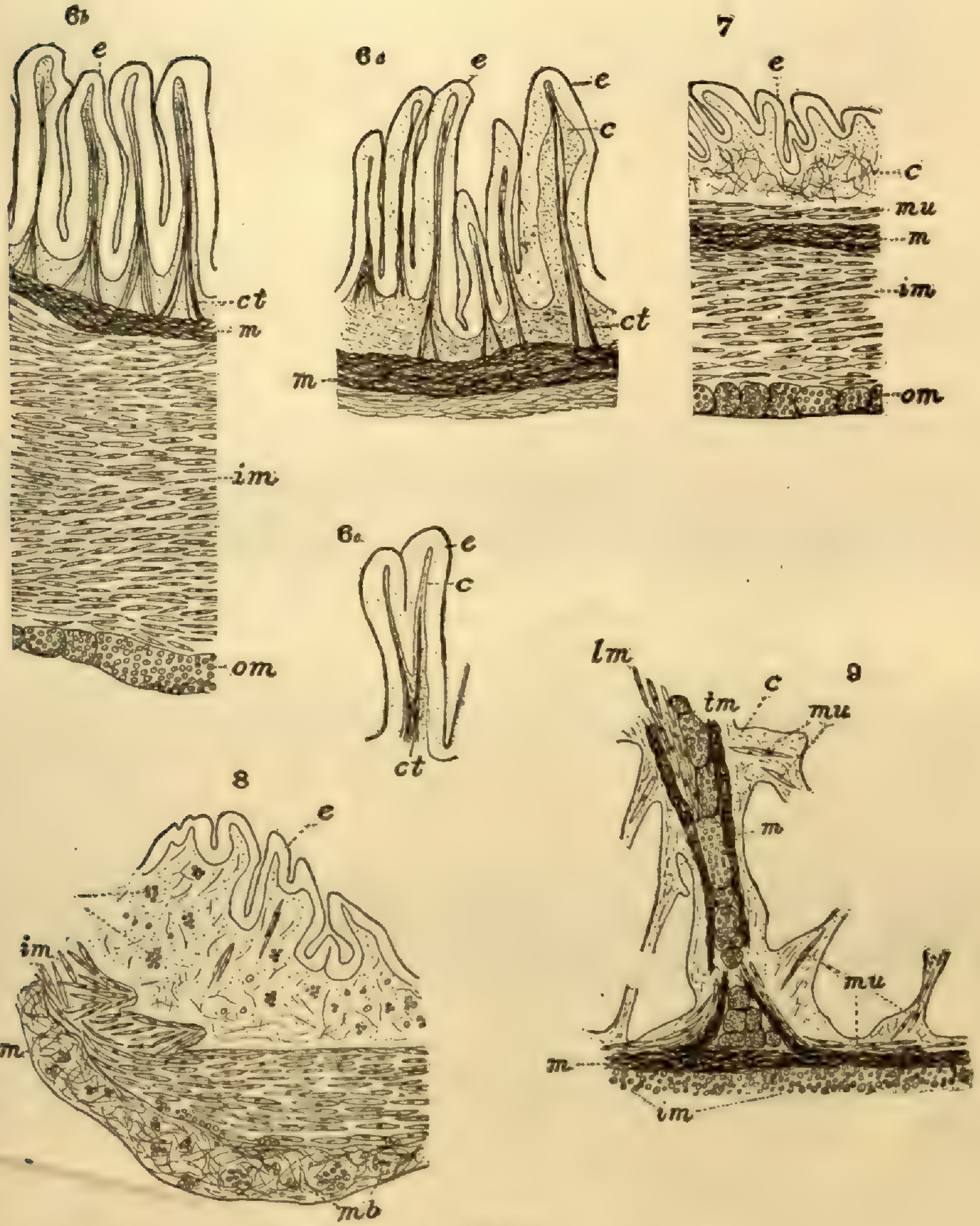
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PLATE II.

EXPLANATION OF PLATE III.

Epithelium under 1/12 in. oil immersion objective; *s.*, striated border; *n.*, nucleus; *g.*, goblet cell; *c.*, cell body.

FIG. 10 (a), (b), (c). Sections of epithelium from the first part of the intestine.

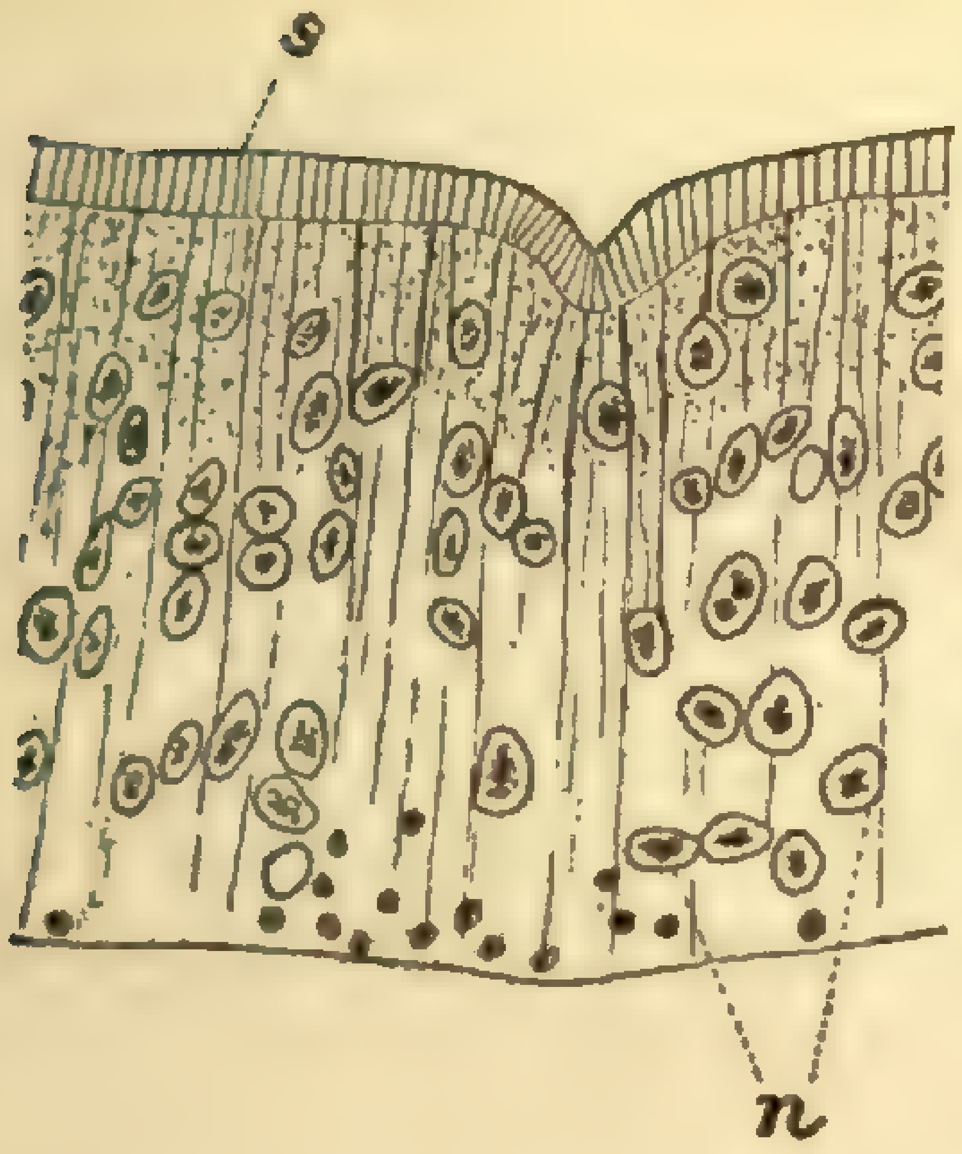
FIG. 11. Section of epithelium from the spiral valve.

FIG. 12. Section of epithelium near caudal end of the intestine.

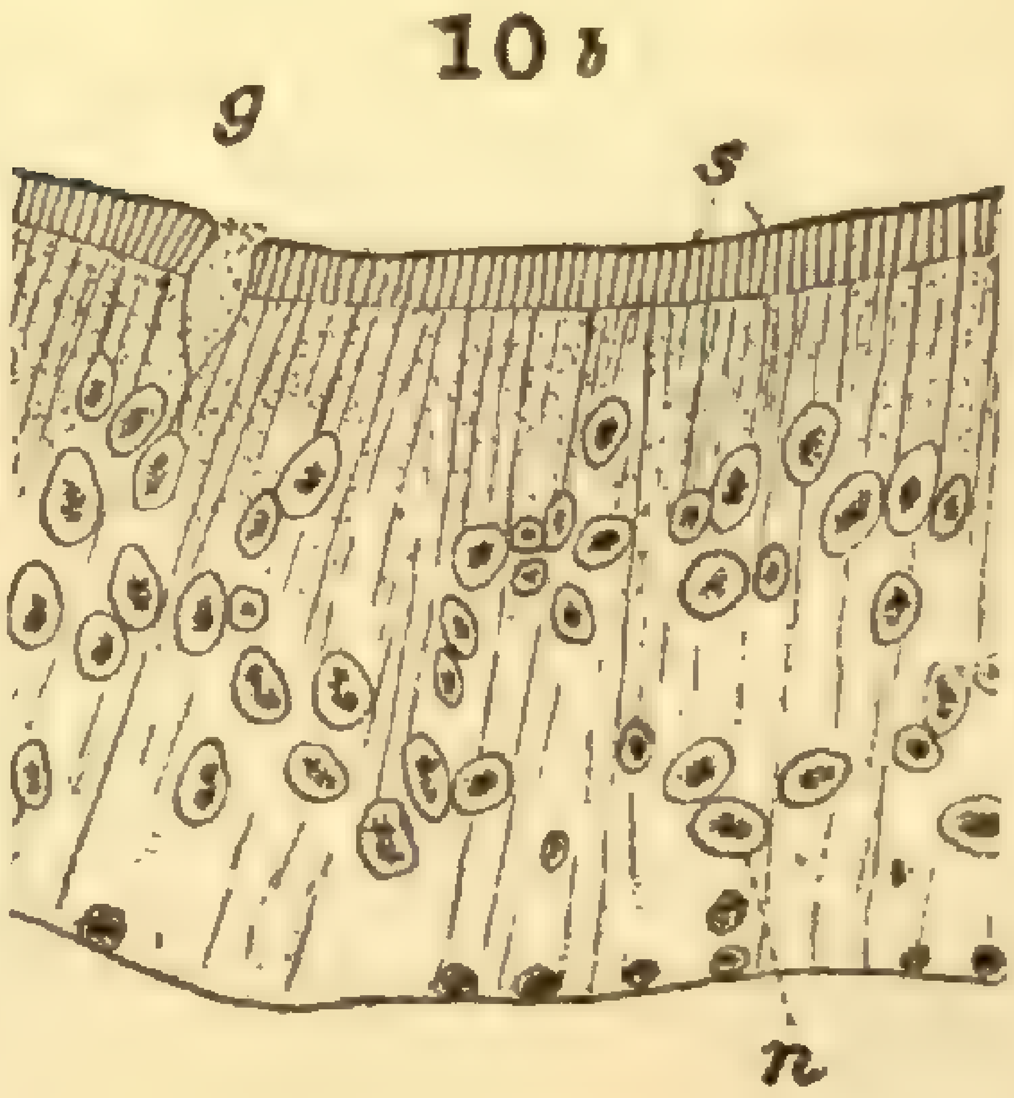
FIG. 13. Isolated epithelial cells showing nuclei at all levels.

(All figures × 350).

10 a

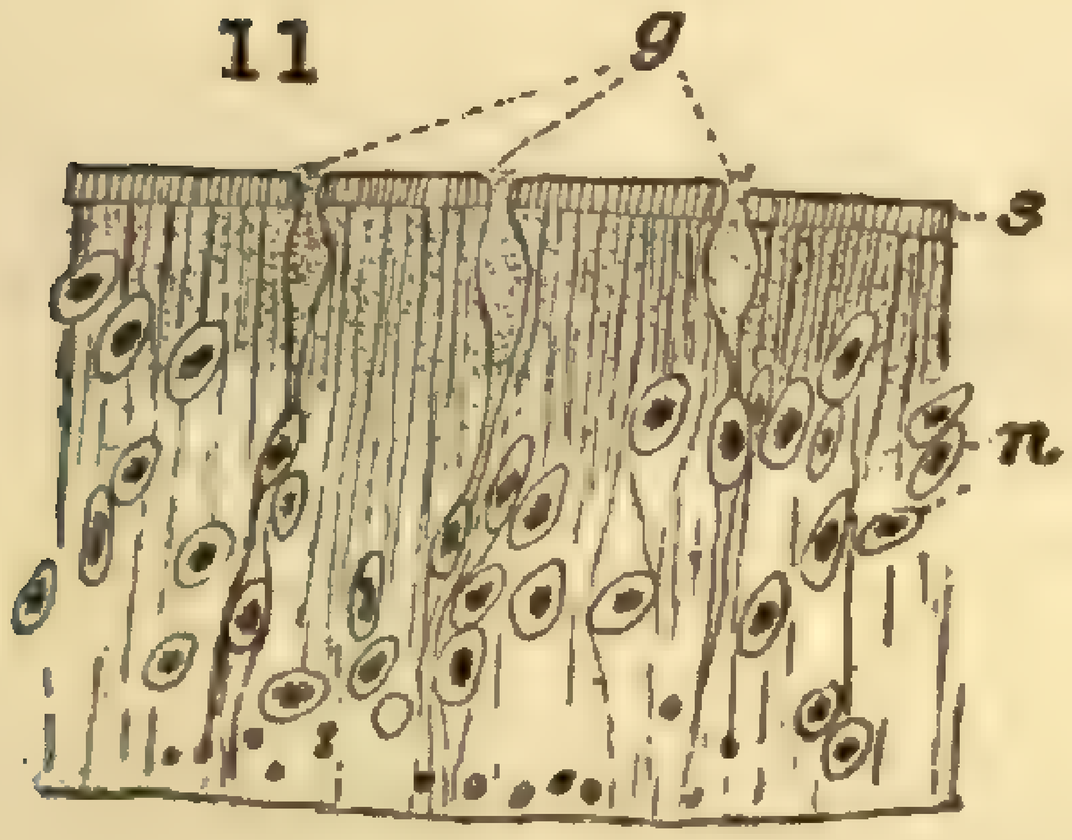


10 b



10 c

11



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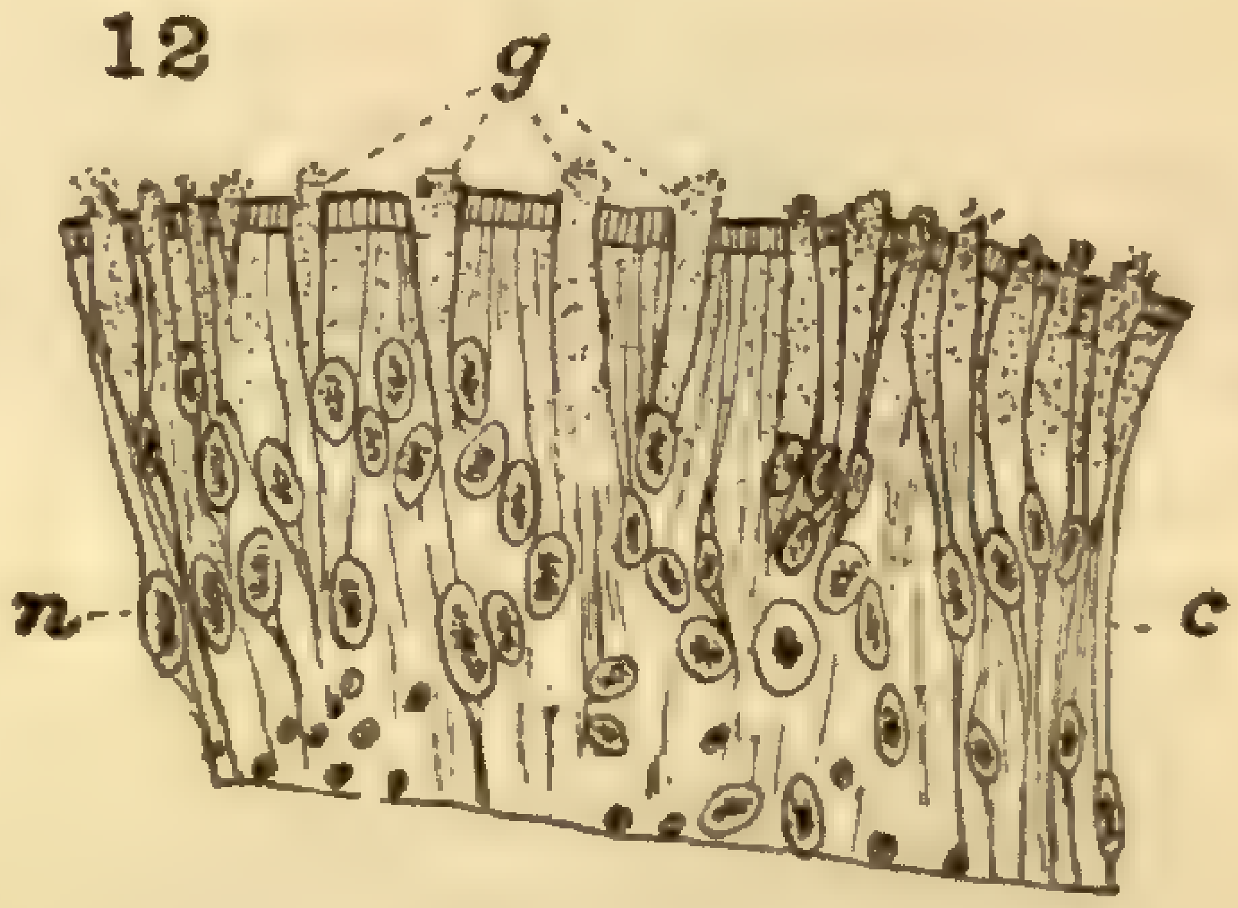

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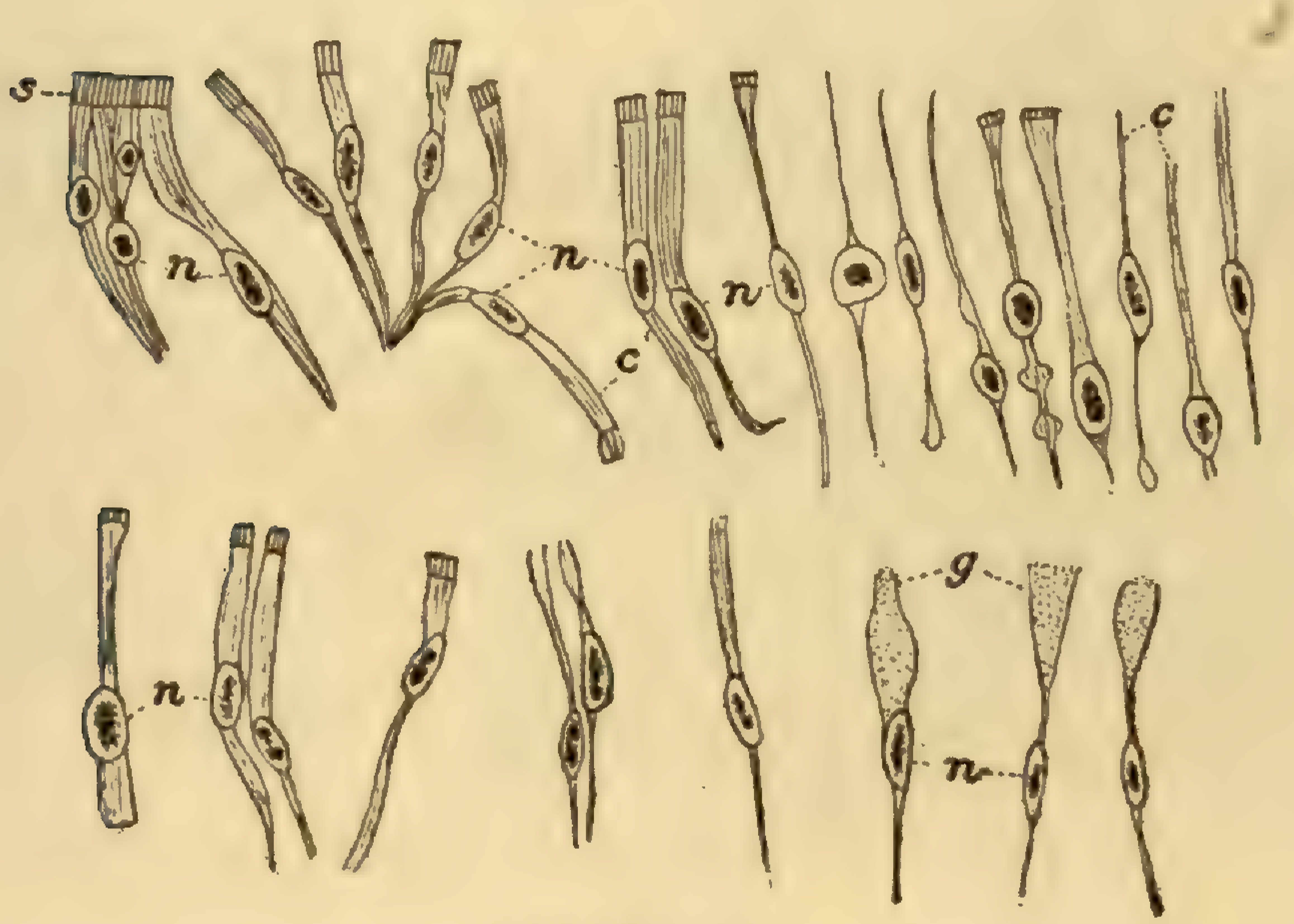


PLATE III.

EXPLANATION OF PLATE IV.

Injected folds and villi, cores of villi alone represented, except in Fig. 19.

FIG. 14. Villus near the pylorus. × 70.

FIG. 15. Villi below the spiral valve. × 70.

FIG. 16. Villus or part of fold on the spiral valve. × 70.

FIG. 17. Villus or part of fold below the pylorus. × 70.

FIGS. 18, 19. Folds from near the pylorus less highly magnified than the above, showing the usual main arterioles with the network of capillaries, and also that the network in these cases is continuous. × 39.

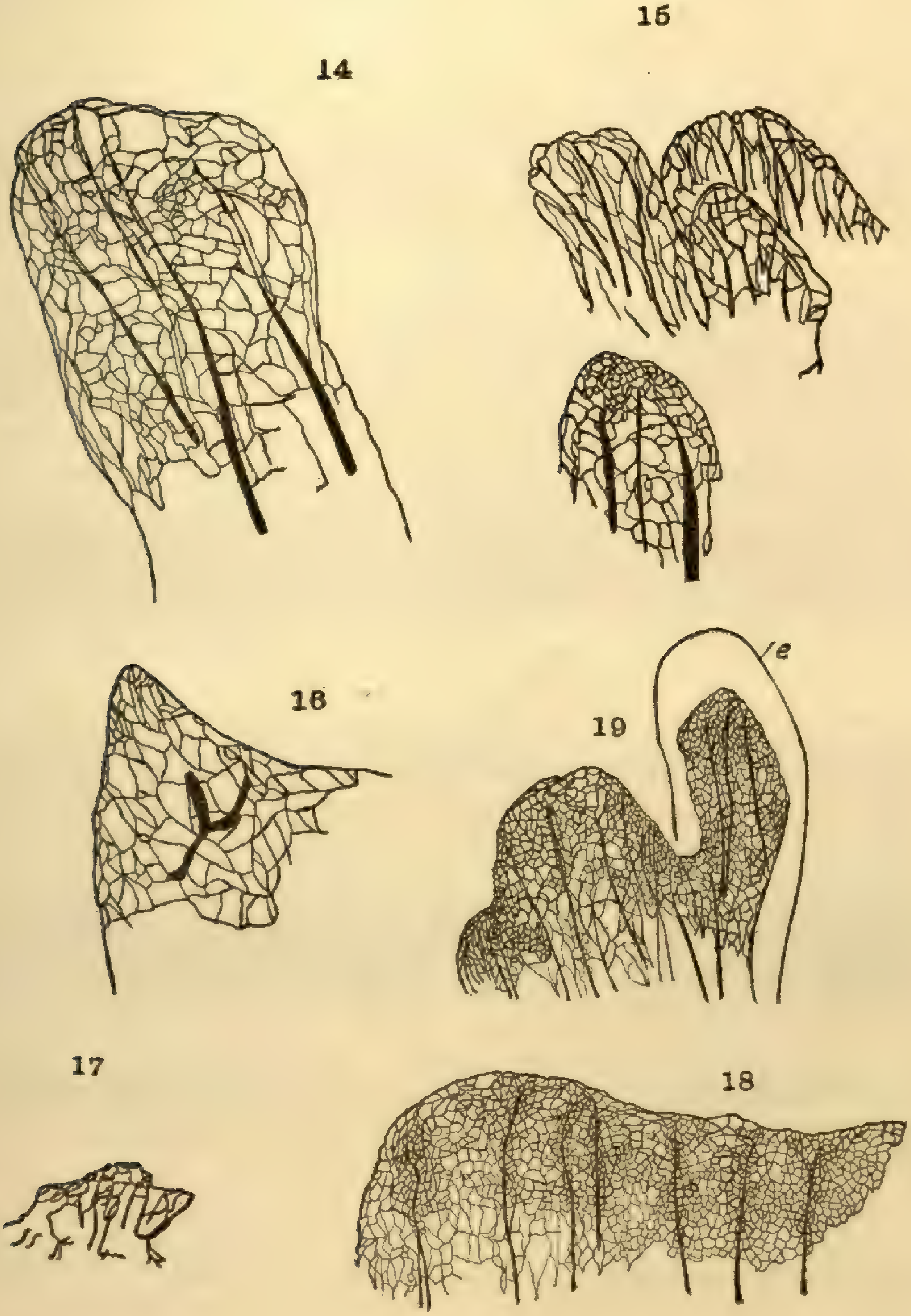


PLATE IV.

STUDIES IN CRANIAL VARIATION.

FRANK RUSSELL.

THERE are a number of characters of infrequent occurrence in the human cranium that are said to have considerable importance as criteria of race. The morphological significance of some of them is not yet known. The present study is almost wholly statistical; it has been carried out upon a collection of Amerindian crania which are not so well known as those of Old World peoples. Nearly two thousand skulls in the Peabody Museum at Harvard University were examined. Many of these are in a fragmentary condition, so that the number available for the study of one character may be very different from that of another, *e.g.*, statistics relating to the metopic suture may be tabulated when the frontal bone alone is present, but those relating to the hard palate can be reckoned only upon skulls that are nearly complete.

Metopic Suture. — The median frontal suture (Fig. 1) closes normally in the infantile skull during the second year. It remains open throughout life, however, in a certain number of cases that is fairly constant for each of the main divisions of mankind. This percentage of open metopic suture varies widely in the different groups, as, for example, between Europeans (8.7 per cent) and Australians (1 per cent). The morphology of metopic crania has been exhaustively treated by Dr. Papillault,[1] who has shown that they are higher and broader, in a word have greater capacity than the normal. The percentage of occurrence of the metopic suture in the adult crania of the Peabody Museum collection is seen in the table on the following page.

Tympanic Exostoses. — There is a tendency in all races toward the formation of bony tumors or exostoses in the

[1] Papillault, Dr. G. La suture métopique, etc., *Mém. Soc. d'Anth.*, T. ii, Sér. 3, fas. 1.

	NUMBER.	PERCENTAGE.
Eskimos	52	0
New England	68	2.9
Ohio and Tennessee	681	.8
California	160	1.9
Miscellaneous[1]	260	0
North America	1127	1.1
Peru[2]	458	1.1
Total[3]	1585	1.1

	NUMBER.	PERCENTAGE.	
"Peruvians"	565	3.5	(Anutchin)[4]
Amerinds	426	1.2	"
"	416	.7	(Harrison Allen)[5]

external auditory meatus. The tendency is increased in deformed crania, though it is now believed that such exostoses are not a necessary accompaniment of deformation; in support of this it will be noted that the small series of crania from New Mexico with pronounced occipital deformation exhibit not a single case of tympanic exostosis. I was somewhat surprised to find this condition of more frequent occurrence in the skulls from Ohio and Tennessee (Fig. 2) than in the deformed crania from Peru (Fig. 3). The exostoses varied in size from minute nodules to large tumorous growths and, in several

[1] Including small collections from the Northwest, New York, New Jersey, New Mexico, and the territory occupied by the plains tribes. In subsequent tables the term "miscellaneous" will be applied to the last two groups.

[2] The localities from which the Peruvian crania in the Peabody Museum have come are Ancon, Casma, Grand Chimu, Amacavilca.

[3] Compare the results obtained by Anutchin and Topinard in their investigations upon European crania:

Europeans of both sexes	10.7810 skulls	8.7	per cent metopic (Anutchin).
Catacombs of Paris	10.000 "	9.91	per cent " (Topinard in his *Éléments d'Anthropologie Générale*, p. 793).

[4] Anutchin, D. N. Reviewed by M. C. Merejowsky in *Rev. d'Anth.*, T. vi, Sér. 2, p. 360.

[5] Allen, Harrison. Crania from the Mounds of the St. John's River. *Journ. Acad. Nat. Sci.*, Philadelphia, New Series, vol. x, No. 4.

instances, to complete occlusion of the external auditory meatus. Dr. Whitney has called attention to the fact that when one lip only of the tympanic ring is affected, it is commonly the inferior.

Frontoparietal. — To economize space I have combined some of the characters in the tables; the somewhat rare anomaly known as the frontoparietal (Figs. 4, 5) may be placed here for convenience.

	Tympanic Exostoses.		Frontoparietal.	
	Number.	*Percentage.*	*Number.*	*Percentage of Occurrence.*
Eskimos	51	0	52	1.9
New England	64	0	64	0
Florida	58	5.2	57	0
Ohio and Tennessee	456	15.1	468	1.1
New Mexico	22	0	22	0
California	158	1.2	159	0
Miscellaneous	66	3.	62	1.6
Mexico	47	8.5	52	0
North America	865	9.2	884	.7
Peru (Ancon, Arica), etc.	447	5.4	449	.2
Total	1312	7.9	1333	.5

Parietal Foramina. — As these foramina are exceedingly variable, statistics relating to them, while difficult to procure, should be of considerable interest. Observations were made to determine whether any significance attached to their occurrence on the one side or the other, but as none appeared I have disregarded this in the table; "present" may mean on one side or on both. Owing to the fact that the foramina are frequently present, yet of extremely small size, and that the condition of many skulls obscures this character, it was found to be almost impossible to obtain accurate data. However, the table will be found to be very nearly correct. Enlarged foramina were discovered in only one group — three cases among crania from the aboriginal cemetery at Madisonville, Ohio.

Epactal Bone. — It is difficult to tabulate the variations occurring in the size and shape of supernumerary occipital

	Number.	Percentage Present.
Eskimos	52	61.5
New England	63	47.6
Florida	56	44.7
Ohio and Tennessee	515	50.3
New Mexico	21	61.9
California	158	67.1
Miscellaneous	61	54.1
Mexico	54	62.9
North America	928	53.8
Peru	447	70.3
Total	1375	59.2

bones. The true interparietal, the composite and incomplete epactals may be distinguished with tolerable certainty, but the smaller bones at the apex of the occipital are not so readily identified. Following Washington Matthews,[1] I have considered all Wormian bones at the lambda as falling in the class designated *os triquetrum seu apicis*.

	Number.	Percentage.				
		Complete.	*Composite.*	*Incomplete.*	*Os quadratum.*	*Os triquetrum seu apicis.*
Eskimos	49	4.0	0	0	0	2.0
New England	66	3.0	0	0	0	0
Florida	62	4.9	1.6	0	0	11.7
Ohio and Tennessee	581	4.1	.9	.2	.5	3.1
New Mexico	21	0	0	0	0	0
California	159	1.9	0	0	1.2	4.7
Miscellaneous	69	0	2.8	0	0	13.0
Mexico	57	1.8	1.8	0	0	12.3
North America	1005	3.3	.9	.1	.5	13
Peru	451	1.8	1.8	.5	1.1	21.5
Total	1456	2.9	1.2	.3	.7	15

It will be observed that the complete or true interparietal bone occurs more frequently among North American tribes than among Peruvians. This is in harmony with the results

[1] The Human Bones in the Hemenway Collection, *Mem. Nat. Acad. Sci.*, vol. vi, p. 198.

obtained by Dr. Matthews from an examination of Cibolan (New Mexican) crania. Professor Boas informs me that some northwest coast tribes exhibit a high percentage of occipital anomalies. Compare Anutchin's[1] tables with the above.

	Number.	Complete.	Os Quadratum.
Amerinds "except Peruvians" . .	390	1.30	.26
"Peruvians"	664	5.46	1.05

As Anutchin's observations were made upon crania that were less uniformly deformed, they were probably in part of another tribe. This illustrates the desirability of abandoning the loose and unscientific term "Peruvians."

Platybasic Crania. — Occasionally a skull is found that has the occipital condyles and adjoining portions of the base thrust upward, as it were, into the cranial cavity. Presumably due to a greater or less degree of yielding of the floor of the calvaria to weight and muscular tension, it naturally occurs in all stages of development, according to the conditions. It is, therefore, difficult at times to distinguish between normal and platybasic crania; Topinard describes three varieties. Only well-marked examples are here noted. The results so far as they go seem to show that no relation exists between this condition and either cephalic index or artificial deformation. The highest percentage of occurrence is found among the Eskimos, who have the largest cranial capacity, but the number of skulls is too small to attach much significance to this.

Jugular Process. — The above table includes statistics concerning this somewhat rare anomaly, in which the process is enlarged until it extends beyond the plane of the condyles (Fig. 6). It is homologous with the paramastoid of the dog, etc. It occurs about once in one hundred crania from Peru and somewhat less frequently in North America.

Aymará Fossa. — Particular interest attaches to this character (Figs. 7, 8), owing to its supposed frequency of occurrence in the crania of criminals. As the fossa is very variable in

[1] *Rev. d'Anth.*, T. vi, Sér. 2, p. 143.

	Platybasic Crania.		Jugular Process.	
	Number.	*Percentage.*	*Number.*	*Percentage.*
Eskimos	49	6.1	48	2
New England	51	2	45	0
Florida	55	0	38	0
Ohio and Tennessee	477	.2	359	.5
New Mexico	21	0	21	4.8
California	158	.6	155	0
Miscellaneous	57	1.7	55	0
Mexico	52	0	48	2.1
North America	871	.5	721	.5
Peru	447	0	439	.9
Total	1318	.3	1160	.7

depth, care must be exercised, and it is practically impossible to wholly eliminate the "personal equation"; only cases in which an actual concavity exists are here noted. While it is of slightly more frequent occurrence among the crania from the coast of Peru than in those from the northern continent, it will be observed that it is by no means confined to southern tribes, as is shown by the high percentage among the Eskimos.

	Aymará Fossa.		Fused Atlas.		Torus Palatinus.	
	Number.	*Percentage.*	*Number.*	*Percentage.*	*Number.*	*Percentage.*
Eskimos	49	10.2	48	0	43	18.6
New England	50	6	46	2	48	8.3
Florida	47	8.5	36	0	8	0
Ohio and Tennessee	425	3.7	358	.8	377	19.1
New Mexico	21	0	21	0	21	9.5
California	158	3.8	155	0	158	11.4
Miscellaneous	55	1.8	54	0	51	7.8
Mexico	47	6.4	47	0	42	4.7
North America	803	4.1	717	.6	704	14.4
Peru	437	5.9	438	.2	436	.2
Total	1240	4.8	1155	.4	—	—

Fused Atlas. — As might be expected, the Ohio-Tennessee collection contained several skulls having their condyles firmly joined with the atlas, sometimes resulting in the almost com-

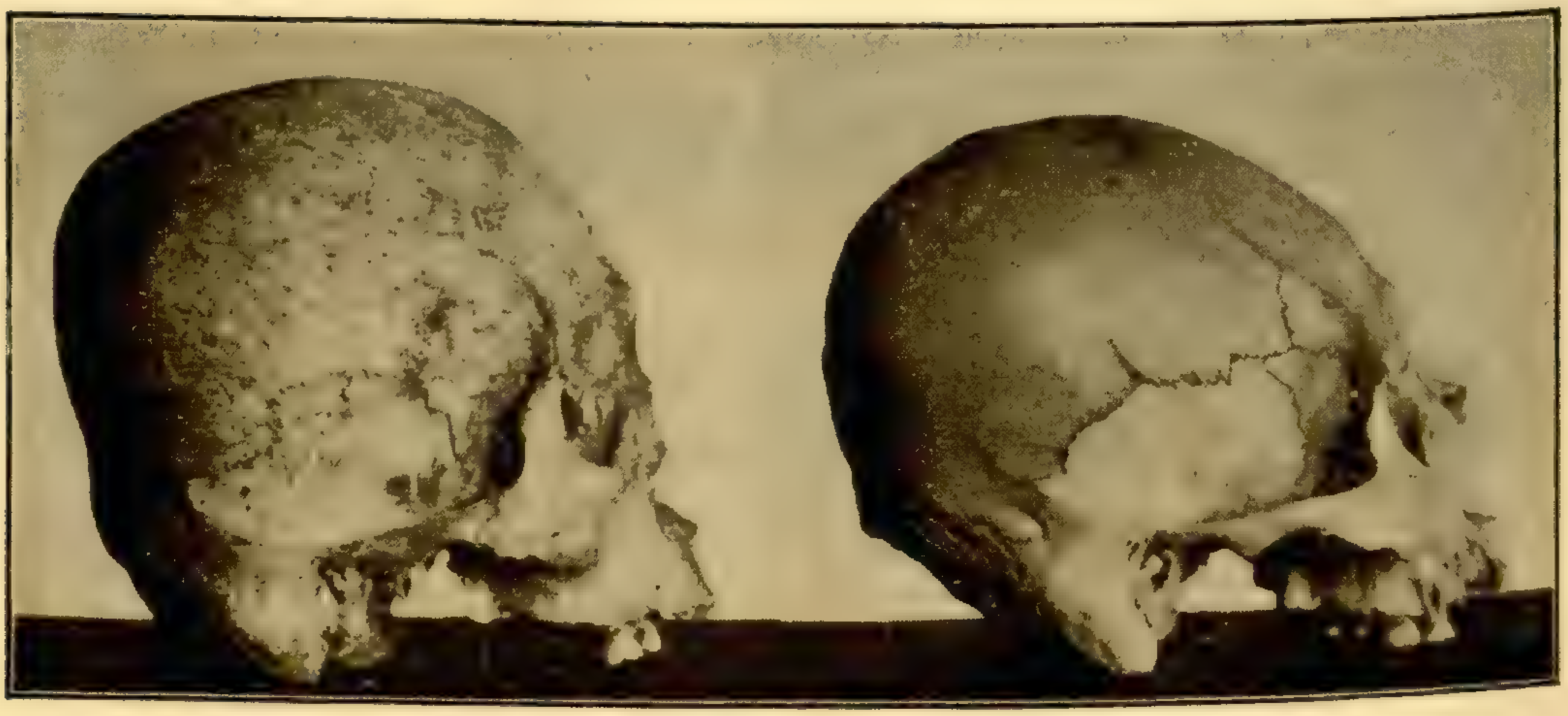
plete absorption of the latter. Crania and skeletons from that region exhibit a large percentage of all kinds of malformations — atavistic, artificial, and pathological.

Torus Palatinus. — This hyperostosis of the middle line of the hard palate is most pronounced in the Eskimo crania. It was slightly more frequent in the Ohio collection (Fig. 9), though the ridges were not so large. With the exception of these two groups, this anomaly appears to be fairly uniformly distributed in North America. The number of skulls from Florida upon which this character could be noted is so small that it would be extremely hazardous to assume southern affinities for this group, because it resembles those of South America, where the percentage of occurrence of this anomaly is so low that I have not combined it with that of North America to form a total for the race. The Florida series also stands apart from all others studied in having a larger percentage of "pterion in K."

In addition to the above characters, observations were made to determine the percentage of occurrence of the infraorbital suture, right and left; of "pterion in H," etc.; as to whether the malar entered the spheno-maxillary suture; the number of bipartite malars (one case to the thousand skulls); and concerning the morphology of an anomalous process at the basion that was found three times in the whole collection. However, I have regarded these characters, somewhat arbitrarily perhaps, of less interest than those considered above and shall not publish the data relating to them.

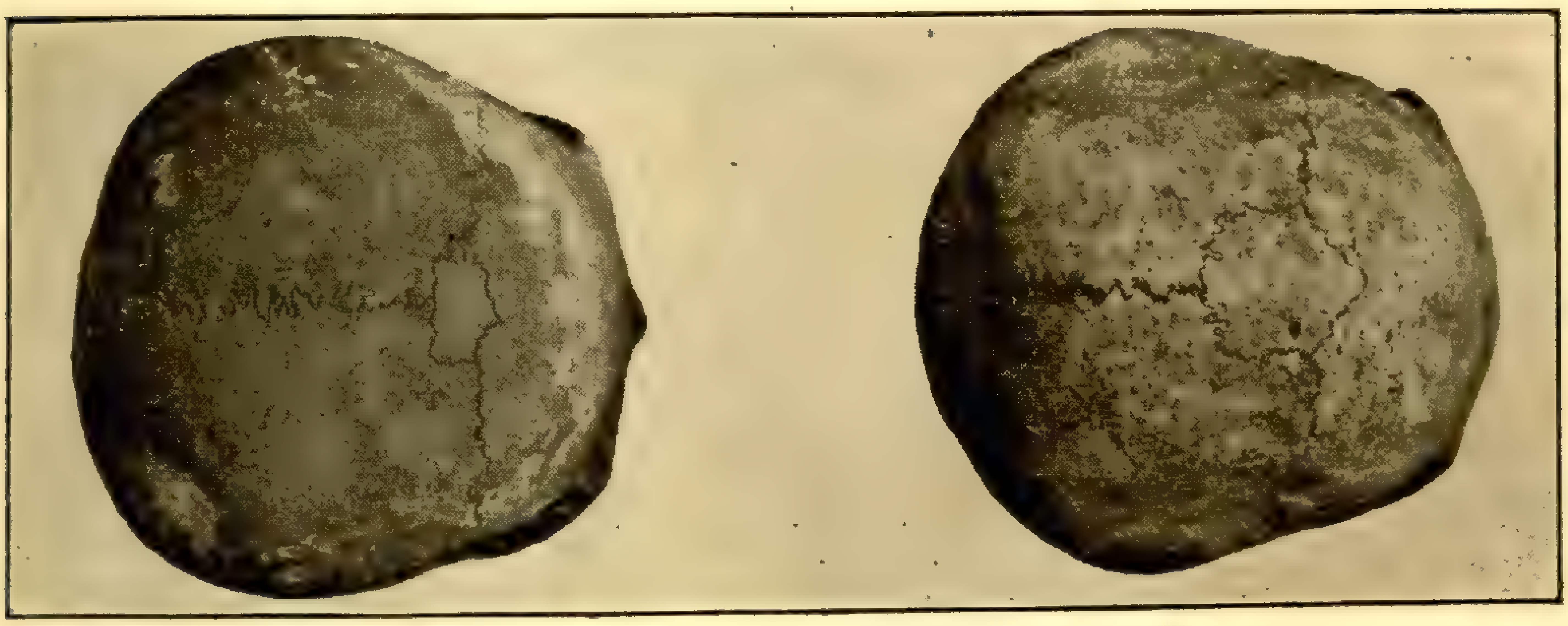
I hope that the facts presented may prove suggestive and interesting, but do not expect them to establish firmly any hypotheses regarding the origin or affinities of the Amerinds.

1



2 3

FIG. 1 — Metopic suture. Grand Chimu, Peru. Cat. No. 480.
FIG. 2. — Tympanic exostoses. Ancon, Peru. Cat. No. 23,407.
FIG. 3. — Tympanic exostoses. Stone Grave, Nashville, Tennessee. Cat. No. 12,802.



4 5

6 9

8 7

FIGS. 4, 5. — Frontoparietal. Stone Grave, Nashville, Tennessee. Cat. Nos. 2600, 17,314.
FIG. 6. — Jugular process. Lynville, Wisconsin. Cat. No. 11,252.
FIG. 7. — Interior of white skull, showing normal internal occipital crest.
FIG. 8. — *Aymard fossa*. Casma, Peru. Cat. No. 447.
FIG. 9. — *Torus palatinus*. Stone Grave, Nashville, Tennessee. Cat. No. 18,280.

SYNOPSES OF NORTH-AMERICAN INVERTEBRATES.

XIII. The Actiniaria.

G. H. PARKER.

The Actiniaria, or sea anemones, are marine animals inhabiting the shallow and deeper waters of our coasts, and usually found attached to some rock or other firm object. They have been justly noted for their exquisite colors and forms. As a rule, each species is represented by separate individuals or *polyps*, but in the Zoantheæ (Fig. 22) colonies are formed by budding, much as in many corals. The sea anemones are further characterized by the fact that they produce no independent skeleton and that their tentacles are very usually simple or undivided. In the more typical species the polyp has the form of a short cylinder, the attached end of which is known as the *pedal disk*, the free end the *oral disk*, and the intermediate part the *column*.

The pedal disk is the organ of attachment for those species that are fixed and the chief organ for locomotion for those that move. It is usually well developed, but in species inhabiting muddy or sandy bottoms it is either reduced, as in Ammophilactis (Fig. 12), or entirely absent, as in the Edwardsiæ (Fig. 1) and the Ceriantheæ (Fig. 21).

The column is generally undivided, but in Halcampa (Fig. 3) as many as three parts can be distinguished: a pedal *physa* of small extent, an intermediate *scapus* corresponding to the column in the restricted sense, and an oral *capitulum*, which often suffers involution when the polyp contracts. The surface of the column is either smooth or more or less covered with eminences, known as *tubercles* (Figs. 9, 10). In the Sagartinæ (Fig. 17) the column wall is very usually pierced by pores, *cinclides*, through which water from the internal cavity of animal and

nettling filaments, *acontia*, may escape. The cinclides are sometimes borne on tubercles, which are then called *cinclidial tubercles*. In rare cases, as, for instance, Epiactis (Fig. 8), the eggs seem to be carried in pits on the column, and the young may be retained in these egg pits for a considerable period. The oral edge of the column is at times characterized by a series of enlargements that are probably neither tubercles nor tentacles, but have been called *marginal spherules*. Usually the oral edge of the column passes directly over into the tentacle-bearing portion of the oral disk. In some species, however, a fold is interpolated in this region, giving rise to what has been called a *collar*. The column, though usually strictly naked, may be covered with a slight secretion, *cuticula*, which may be firm and rough, as in Phellia, or slightly adhesive, so as to accumulate sand particles, as in Epizoanthus.

The oral disk carries the circle of *tentacles*. These are hollow processes from the wall of the disk and are usually pointed, though sometimes blunt or even club-shaped, as in Eloactis (Fig. 4). They are usually firmly attached to the oral disk, but in Bolocera (Fig. 6) the region of attachment is marked by a well-developed circular muscle, by whose contraction the base of the tentacle may be much constricted or even cut through, thus setting the tentacle free. As a rule, the tentacles cover a single circular area intermediate in position between the mouth and the margin of the oral disk. In Cerianthus (Fig. 21), however, they form two distinct bands, one *marginal* (principal) and the other *circumoral* (accessory). The *mouth* lies in the center of the oral disk and is generally surrounded by swollen lips. In Bicidium a portion of the lip is so much enlarged as to produce a projecting proboscis, the *conchula*.

Of the internal structure of the sea anemones little need be said in this connection, as the features upon which the following key is based are chiefly external. The mouth leads into a *gullet* or *œsophagus*, which opens at its pedal end into the one internal cavity possessed by the animal, the *gastrovascular space*. This is partly divided by membranous partitions, or *mesenteries*, that start from the inner surface of the column wall and project centrally. From the inner edge of the mesenteries come

the nettling filaments, or acontia, already mentioned. The line of attachment of a mesentery to the column wall is often marked, as in the Edwardsiæ (Fig. 1), by a depressed line or furrow on the exterior of the column.

A second internal feature of importance is the *sphincter*, or circular muscle, in the region between the oral disk and the column. This muscle, by virtue of which the upper part of the column may be puckered over the oral disk when this is contracted, lies either in the intermediate layer of the body wall (mesoglœa), as in the Paractidæ, or in the inner layer (endoderm), as in the Bunodidæ. These distinctions are not easily made out unless the region in question is examined microscopically. When the sphincter is poorly developed, as in the Boloceridæ, the polyps, even when contracted, usually leave their tentacles exposed.

The following key gives the species of Actiniaria recorded for North America at depths within 100 fathoms of the surface and occurring north of Florida on the east coast, and north of southern California on the west coast. In indicating the geographical range the following abbreviations have been used:

N., Arctic Ocean to Cape Cod.
M., Cape Cod to Cape Hatteras.
S., Cape Hatteras to Florida.
A., Arctic Ocean to Puget Sound.
P., Puget Sound to San Francisco.
D., San Francisco to Southern California.

Key to the Tribes of the Suborder Actiniaria.

1. Colonial . . . . Zoantheæ 58
1. Not colonial 2
2. Tentacles in two circles, one marginal (principal) and the other circumoral (accessory) . . . . Ceriantheæ 56
2. Tentacles in a single circle 3
3. Column smooth, wrinkled, or with longitudinal furrows, at least twelve in number (six pairs of mesenteries) . . . . Hexactiniæ 7
3. Column with eight longitudinal furrows (eight mesenteries) Edwardsiæ 4

Genera and Species of Edwardsiæ.

4. Tentacles sixteen or fewer . . . . . . Edwardsia 5
4. Tentacles more than sixteen, usually at least twenty-four, Edwardsiella 6
5. Polyp slender; tentacles sixteen; non-parasitic *Edwardsia elegans* Ver., N., low water

5. Polyp very slender, length 30 mm., diameter 1.5 mm.; tentacles sixteen; parasitic on *Mnemiopsis leidyi* . . *E. leidyi* Ver., M.[1]
6. Polyp slender, length 125 mm., though capable of contracting to 35 mm., diameter 4 mm.; tentacles twenty to thirty-six; column with a brownish investment, except at aboral end, which is naked *E. sipunculoides* (Stimp.) Andres, N., low water (Fig. 1)
6. Polyp slender, length 25–35 mm., diameter 2.5–3 mm.; tentacles twenty-four to thirty; column including aboral end with a brownish investment . . . . *E. lineata* (Ver.), M., 4–12 fathoms

FIG. 1.— *Edwardsiella sipunculoides* (Stimp.) Andres. After Verrill.

FAMILIES OF HEXACTINIÆ.

7. Pedal disk absent . . . . Ilyanthidæ 11
7. Pedal disk present 8
8. Acontia present . . . . Sagartidæ 38
8. Acontia absent 9
9. Sphincter diffuse and weak . . . . . Boloceridæ 18
9. Sphincter strong 10
10. Sphincter endodermal (column usually tuberculated) Bunodidæ 20
10. Sphincter mesoglœal (column usually not tuberculated) Paractidæ 31

GENERA AND SPECIES OF ILYANTHIDÆ.

11. Conchula (proboscis) present . . . . . Bicidium 12
11. Conchula absent 13
12. Polyp elongated, length 30 mm., diameter 6 mm., longitudinal sulcations twelve; tentacles twelve; usually parasitic on *Cyanea arctica* *Bicidium parasiticum* Ag., N. (Fig. 2)
13. Column divided into three sections, an oral retractile capitulum, an intermediate scapus, and a pedal physa . . Halcampa 14
13. Column continuous, not divided into sections 15
14. Polyp elongated, length 25 mm., diameter 3 mm.; tentacles twelve *Halcampa farinacea* (Ver.) Andres, N., 8–90 fathoms (Fig. 3)
14. Polyp slender; tentacles about twenty-four *H. pallida* (Ver.) Andres, N., low water
15. Tentacles blunt or club-shaped . . . . Eloactis 16
15. Tentacles tapering to a point . . . . . Ilyanthus 17
16. Polyp much elongated, length 200–250 mm., which may by contraction be reduced to 75 mm., diameter 18 mm., longitudinal sulcations twenty; tentacles twenty *Eloactis producta* (Stimp.) Andres, M., low water (Fig. 4)

[1] Known only as an immature form.

17. Polyp elongated, tapering from oral to aboral end, length 25 mm., greatest diameter 6 mm.; tentacles thirty-six, in two imperfect rows *Ilyanthus lævis* Ver., N. (Fig. 5)

17. Polyp rather slender, tapering from oral to aboral end, length about 90 mm., greatest diameter 18 mm.; tentacles numerous, in several rows . . . . *I. chloropsis* Ver., S.

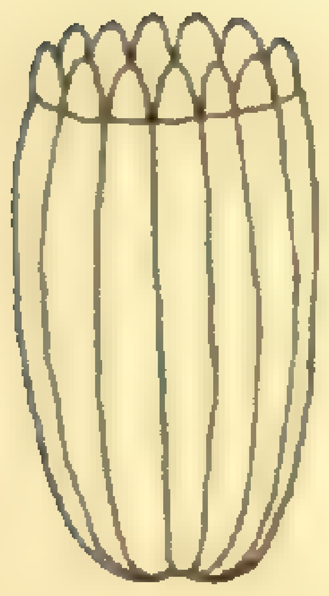


FIG. 2.

FIG. 3.

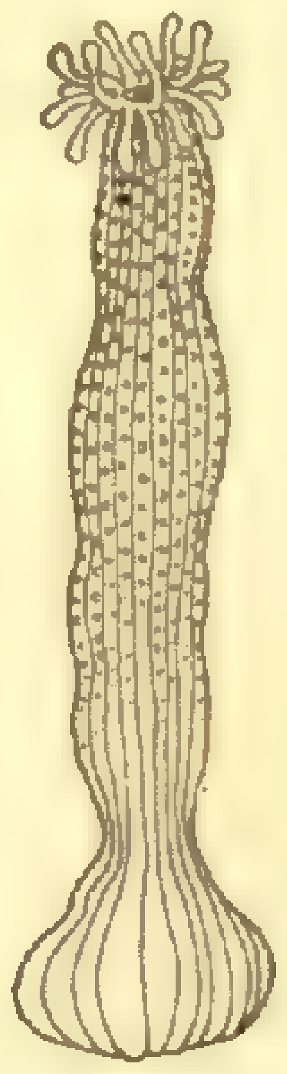


FIG. 4.

FIG. 5.

FIG. 2. — *Bicidium parasiticum* Ag. After Verrill.
FIG. 3. — *Halcampa farinacea* (Ver.) Andres. After Verrill.
FIG. 4. — *Eloactis producta* (Stimp.) Andres. After Verrill.
FIG. 5. — *Ilyanthus laevis* Ver.

SPECIES OF BOLOCERIDÆ.

18. Tentacles with strong sphincter muscles at base (often deciduous) Bolocera 19

19. Polyp broad and low, height about 30 mm., diameter of oral disk about 200 mm.; tentacles several hundred, crowded, in some twenty indistinct rows . . *Bolocera multicornis* Ver., N., 45 fathoms

19. Polyp massive, height about 100 mm., diameter of oral disk 150–250 mm.; tentacles numerous, in some three concentric rows *B. tuediæ* (Johnst.) Gosse, N., 37–365 fathoms (Fig. 6)

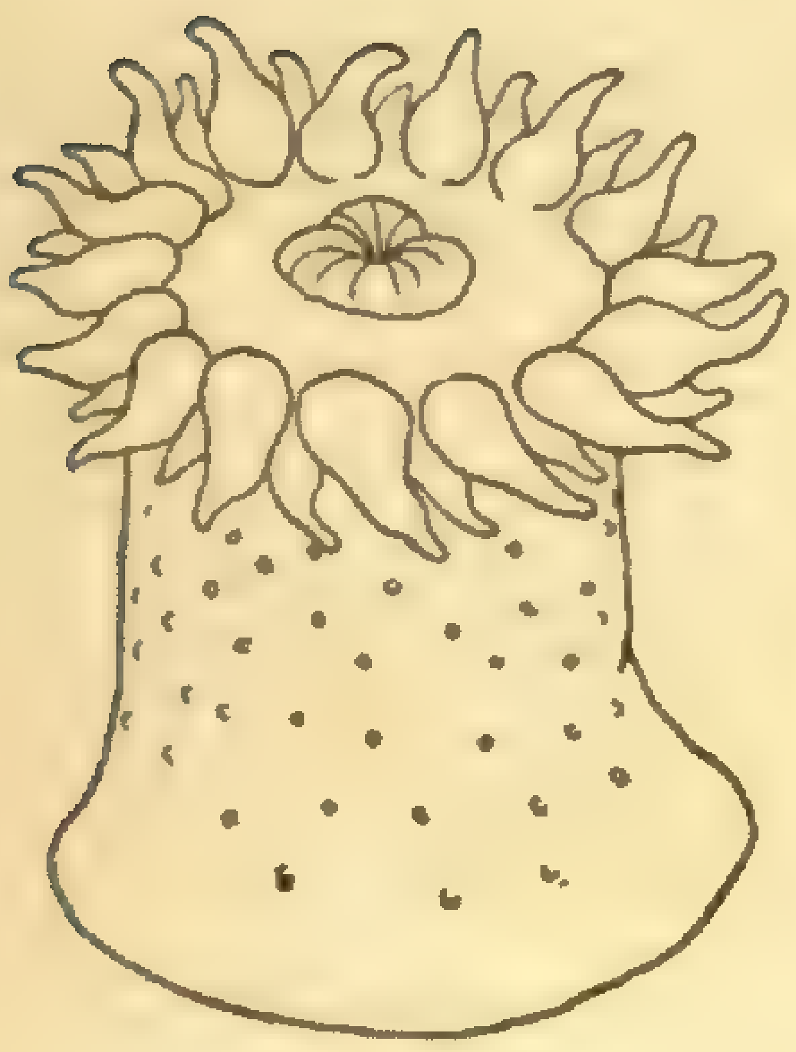


FIG. 6.

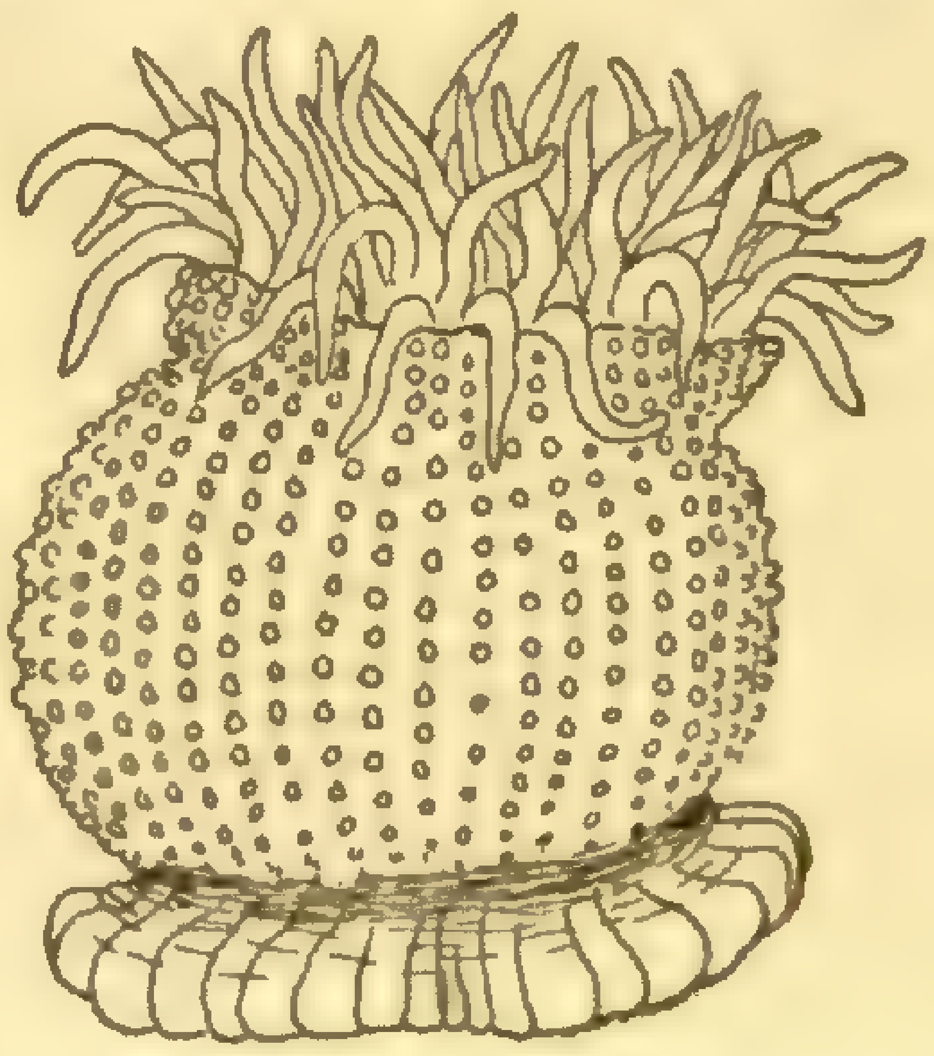


FIG. 7.

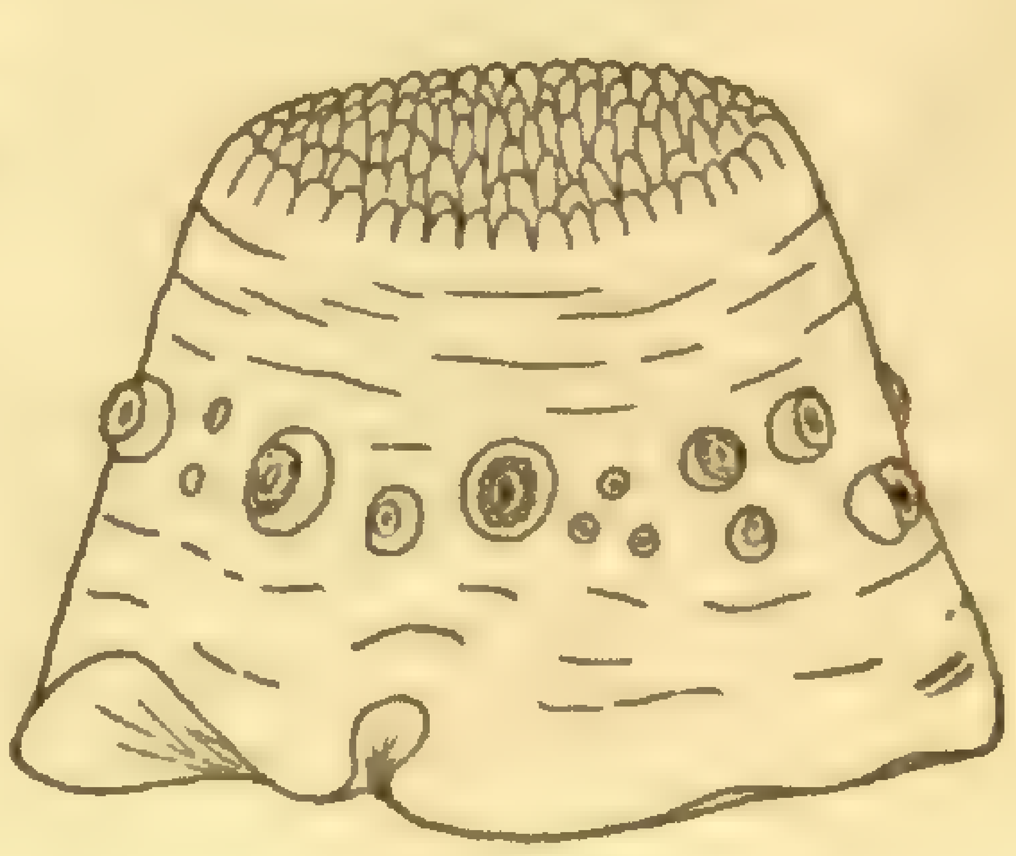


FIG. 8.

FIG. 6. — *Bolocera tuediæ* (Johnst.) Gosse. After Andres.
FIG. 7. — *Evactis artemisia* (Dana) Ver. After Dana.
FIG. 8. — *Epiactis prolifera* Ver. After Verrill.

GENERA AND SPECIES OF BUNODIDÆ.

20. Column perforated by numerous pores through which water may be discharged . . . . Evactis 21
20. Column not perforated by pores 22
21. Polyp broad and low, diameter of oral disk 60 mm.; tentacles in three series . . . *Evactis artemisia* (Dana) Ver., P. (Fig. 7)
22. Column surrounded at its middle by a band of egg pits Epiactis 23
22. Column without egg pits 24
23. Polyp 10 mm. in height, diameter of aboral disk 12 mm.; tentacles about ninety-six; egg pits as many as thirty to forty, often containing young, which then resemble buds
Epiactis prolifera Ver., P. (Fig. 8)
24. Column with scattered tubercles 25
24. Column with tubercles in longitudinal rows 28

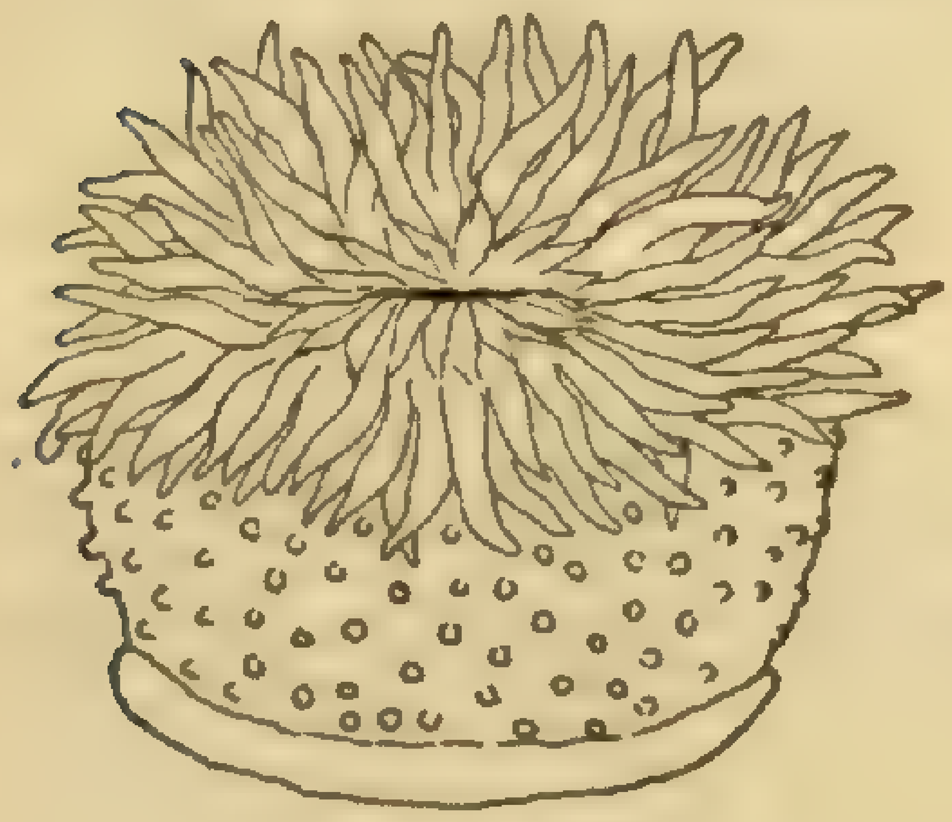


FIG. 9.

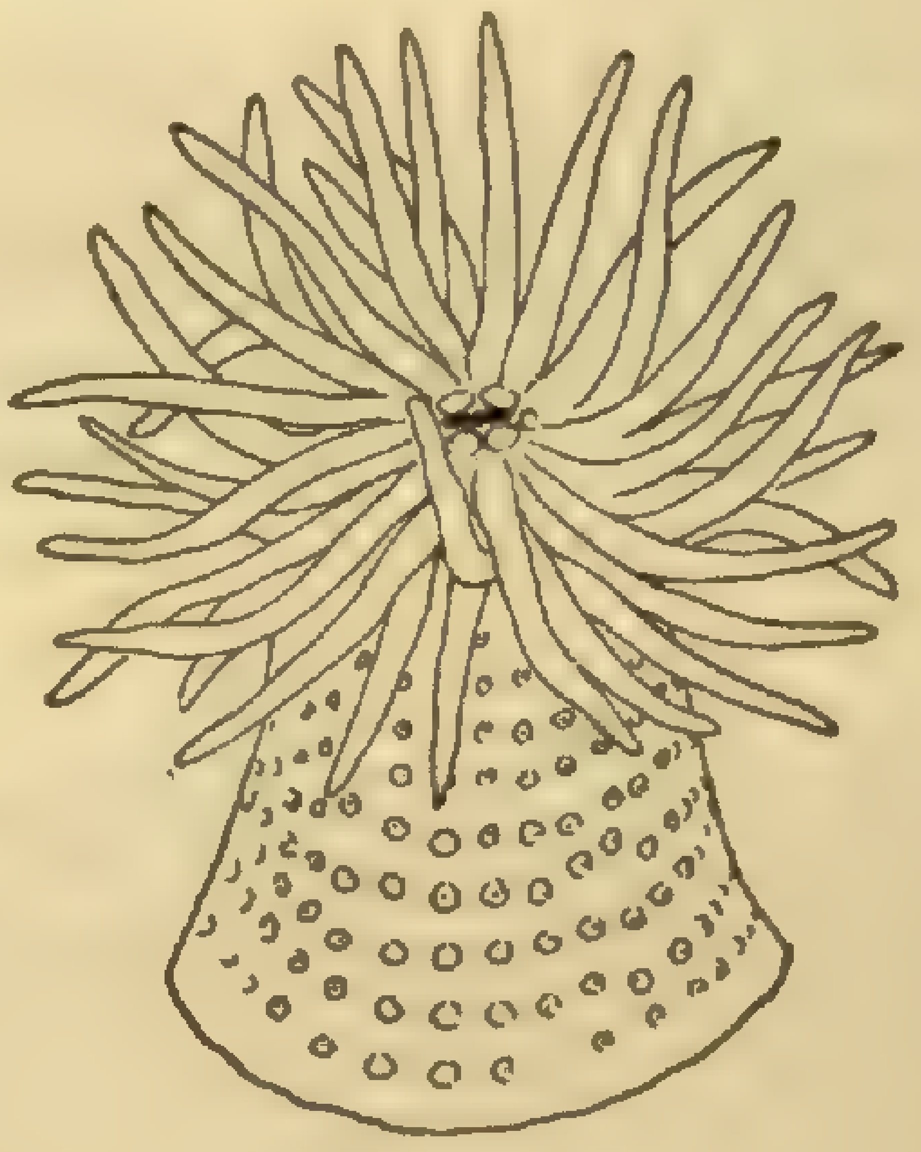


FIG. 10.

FIG. 9. — *Tealia crassicornis* (Müll.) Gosse. After Andres.
FIG. 10. — *Bunodes stella* Ver. After Verrill.

25. Oral edge of column with marginal spherules . . Phymactis 26
25. Oral edge of column without marginal spherules . . Tealia 27
26. Polyp 50 mm. in height, diameter of oral disk 38 mm.; tentacles ninety-six, in four circles
Phymactis cavernata (Bosc) Andres, S., between tides
27. Polyp 50 mm. in height, diameter of oral disk 120 mm.; tentacles 160
Tealia crassicornis (Müll.) Gosse, A., N., 16–40 fathoms (Fig. 9)
28. Tubercles forming rows on column from oral to aboral end Bunodos 29
28. Tubercles limited to oral portion of column . . Aulactinia 30
29. Polyp 50 mm. in height, diameter of oral disk 35 mm.; tentacles large, forty-eight to seventy-two
Bunodes stella Ver., N., tide pools (Fig. 10)
30. Polyp columnar, height 150 mm., greatest diameter 35 mm.; tentacles ninety-six, in four circles
Aulactinia capitata Ver., M., S., low water

Genera and Species of Paractidæ.

31. Inner tentacles many times longer than outer . Actinostola 32
31. All tentacles of about the same length 33
32. Polyp massive, height 150–180 mm., diameter of oral disk 200–250 mm.; tentacles numerous
Actinostola callosa Ver., N., M., 45–300 fathoms (Fig. 11)
33. Diameter of pedal disk much less than that of column Ammophilactis 34

Fig. 11.

Fig. 12.

Fig. 11. — *Actinostola callosa* Ver. After Verrill.
Fig. 12. — *Ammophilactis rapiformis* (Les.) Ver. After Verrill.

33. Diameter of pedal disk as great as that of column or greater . 35
34. Height of column 80 mm., diameter of oral disk 25 mm., of column 12–25 mm., of pedal disk 10–12 mm.; tentacles numerous (144 or more)
Ammophilactis rapiformis (Les.) Ver., M., tide pools (Fig. 12)
35. Sphincter well developed, collar pronounced, especially in contracted specimens . . . . Stomphia 36
35. Sphincter poorly developed, collar scarcely noticeable, even in contracted specimens . . . . Paractis 37

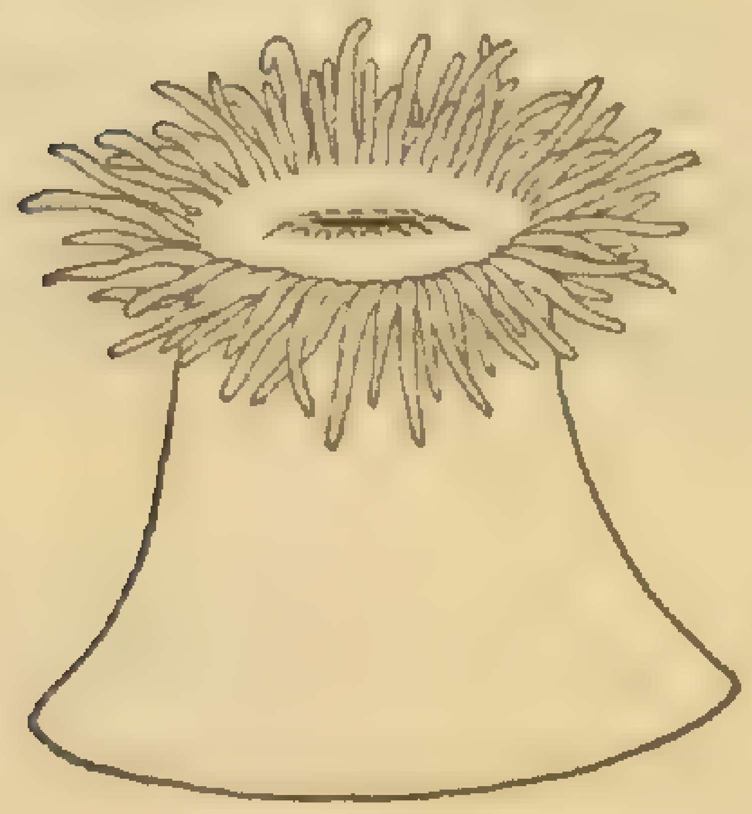


Fig. 13.

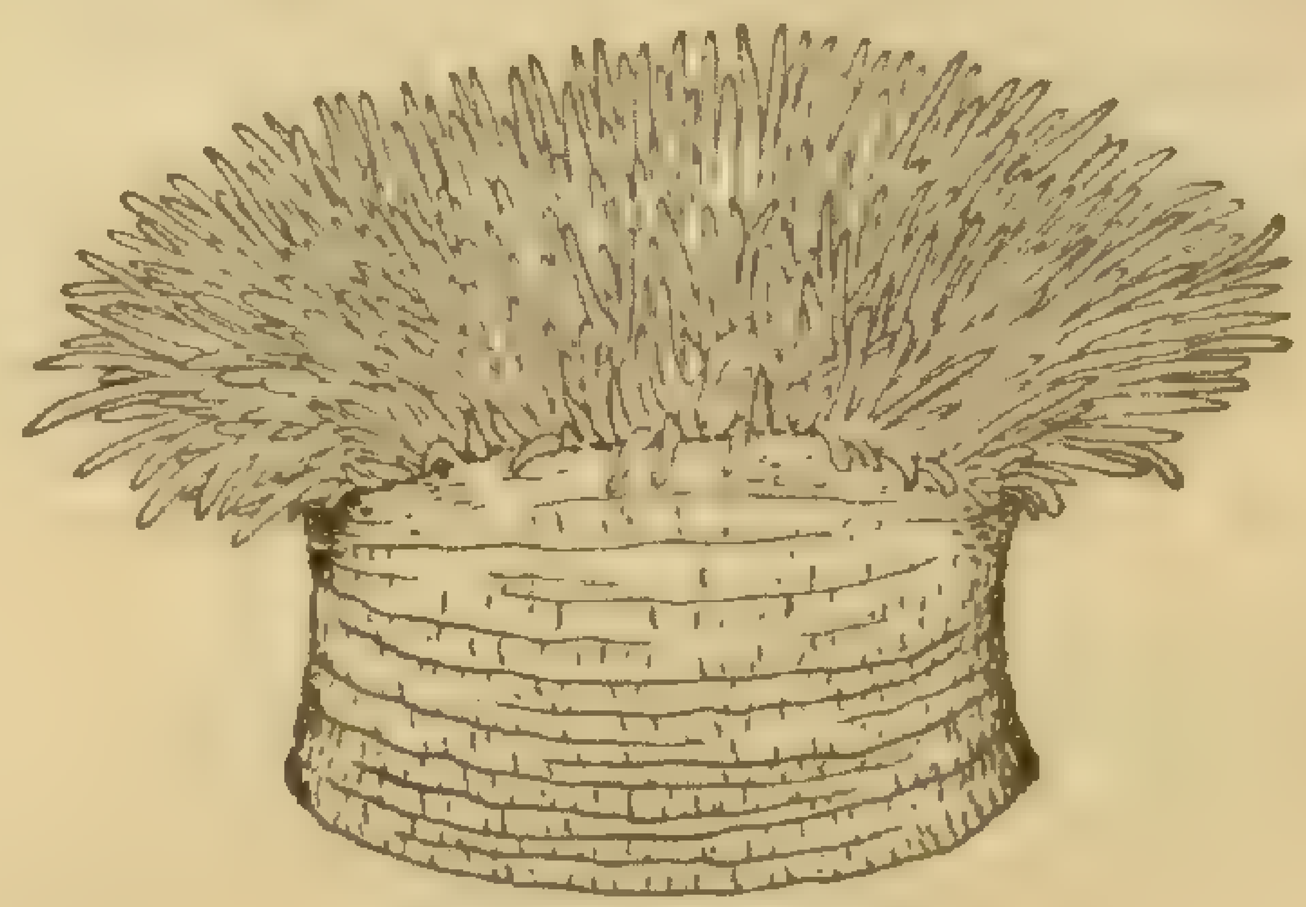


Fig. 14.

Fig. 13. — *Stomphia carneola* (Stimp.) Ver. After Verrill.
Fig. 14. — *Paractis perdix* Ver. After Verrill.

36. Height of column 50 mm., diameter of oral disk about 37 mm.; tentacles ninety-six or more, in two or three crowded marginal rows
Stomphia carneola (Stimp.) Ver., N., 8–35 fathoms (Fig. 13)

37. Height of column 75–100 mm., diameter of oral disk about 125 mm.; tentacles very numerous (about 384)
Paractis perdix Ver., M., 62–192 fathoms (Fig. 14)

SUBFAMILIES OF SAGARTIDÆ.

38. Column divided into two segments, an oral capitulum and an aboral scapus; cinclides usually absent . . . . Phellinæ 53
38. Column undivided; cinclides usually present . . Sagartinæ 39

GENERA AND SPECIES OF SAGARTINÆ.

39. Column wall smooth or with only very slight evidence of tubercles, no cinclidial tubercles 40
39. Cinclidial tubercles present 48
40. Oral disk lobed, tentacles very numerous . . Metridium 41
40. Oral disk not lobed, tentacles numerous . . . Sagartia 42

SPECIES OF METRIDIUM.

41. Column 100 mm. in height, diameter of oral disk 75 mm.; tentacles very numerous, the central ones longest *Metridium marginatum* (Les.) M. Edw., N., M., low water to 90 fathoms (Fig. 15)
41. Polyp as in preceding species but with tentacles longer and more slender . . . . *M. fimbriatum* Ver., P., low water[1]

SPECIES OF SAGARTIA.

42. Tentacles peripheral, so that more than half of the oral disk is exposed 43
42. Tentacles covering oral disk so that very little or none of it is exposed 44
43. Height of column 15–25 mm., diameter 10–20 mm.; tentacles about fifty, in two, three, or more rows, rather small
Sagartia spongicola Ver., M., 72–158 fathoms
44. Height of column less than 10 mm. 45
44. Height of column about 20 mm. 46
44. Height of column 40 mm. or more 47
45. Surface of column smooth, height 5–8 mm., diameter 4–6 mm.; tentacles eighty-four, in four rows, central ones longest
S. luciæ Ver., M., N., tide pools
45. Surface of column broken by longitudinal and transverse furrows, height 6 mm., diameter of pedal disk 10–14 mm., of oral disk 6 mm., tentacles long, sixty-four, in four rows
S. pustulata McMur., M., shallow water

[1] Probably synonymous with *M. marginatum*.

46. Height of column 20 mm., diameter 3–4 mm.; tentacles forty-eight, in four rows . . . *S. gracillima* McMur., M., shallow water
47. Height of column 63 mm., diameter 15 mm.; tentacles about sixty, rather short, length less than the diameter of the oral disk
S. modesta Ver., M., low water (Fig. 16)
47. Height of column 40 mm., diameter 25–35 mm.; tentacles numerous, in three to five rows, longer than the diameter of the oral disk
S. abyssicola (Kor. and Dan.) Ver., N., M., 75–640 fathoms

FIG. 15.

FIG. 16.

FIG. 17.

FIG. 15. — *Metridium marginatum* (Les.) M. Edw.
FIG. 16. — *Sagartia modesta* Ver. After Verrill. On the sides of the column several twisted acontia are seen, their points of exit marking the positions of cinclides.
FIG. 17. — *Cylista leucolena* (Ver.) Andres. After Verrill.

OTHER SPECIES OF SAGARTINÆ.

48. Cinclidial tubercles small, in irregular vertical lines . . Cylista 50
48. Cinclidial tubercles large 49
49. Cinclidial tubercles forming a band around middle of column
Aiptasia 51
49. Cinclidial tubercles forming a band around pedal end of column
Adamsia 52
50. Height of column 63 mm., diameter 10 mm.; tentacles ninety-six, in five rows, slender, and longer than twice the diameter of the column
Cylista leucolena (Ver.) Andres, M., shallow water (Fig. 17)
51. Height of column 38 mm., diameter of oral disk 18 mm.; tentacles ninety-six, in four rows, length of inner tentacles 20 mm., of outer ones 6 mm. *Aiptasia pallida* (Ver.) Andres, S., shallow water
52. Height of column 75 mm., diameter 43 mm.; tentacles very numerous (500 or more in large specimens); on dead shells inhabited by hermit crabs
Adamsia tricolor (Les.) Duch. and Mich., S., shallow water
52. Height of column 10–14 mm.; tentacles numerous, in two circles; young on dead shells inhabited by hermit crabs (*Catapagurus sociális* Smith), later the shell may be dissolved, the polyp having formed a horny hood in which the crab protects its abdomen
A. sociabilis Ver., M., 76–410 fathoms (Fig. 18)

GENERA AND SPECIES OF PHELLINÆ.

53. Capitulum with longitudinal ridges, scapus strongly tuberculate
Actinauge 54

53. Capitulum smooth, scapus granulated . . . . Phellia 55

54. Height of column 80–150 mm., diameter 50–100 mm.; tentacles ninety-six, in five rows
Actinauge verrillii McMur., N., M., S., 50–506 fathoms (Fig. 19)

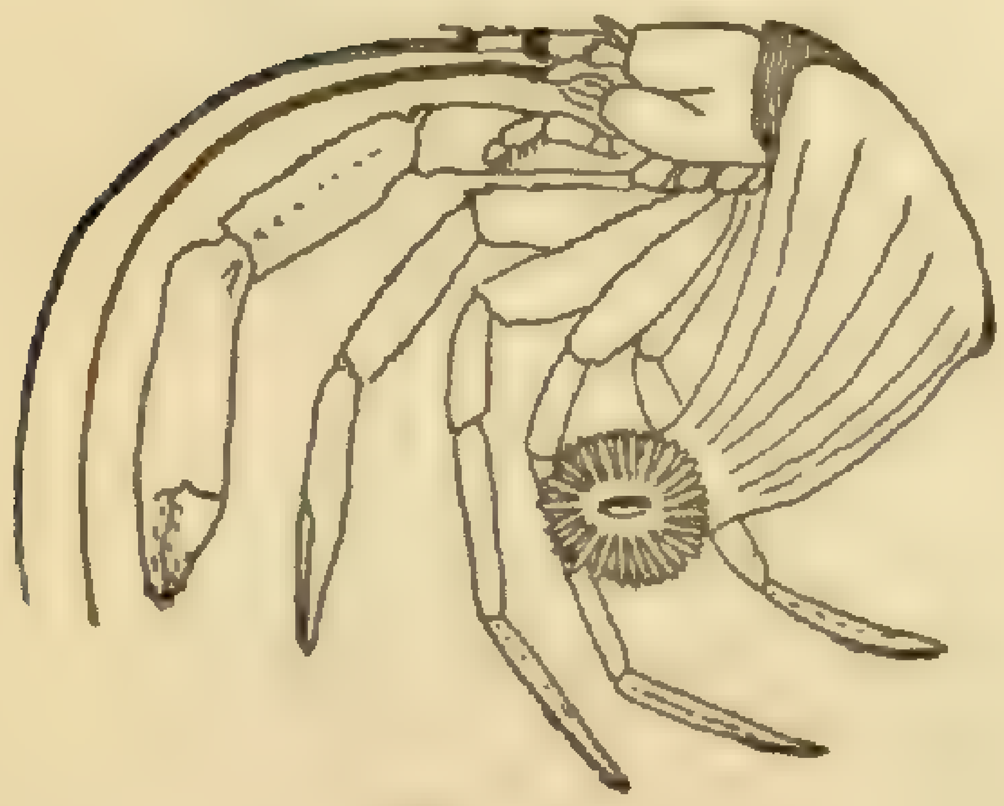


FIG. 18.

FIG. 19.

FIG. 20.

FIG. 18. — *Adamsia sociabilis* Ver. After Verrill. The cinclidial tubercles that occur near the pedal margin of the column in this species are not represented in the figure.
FIG. 19. — *Actinauge verrillii* McMur. After Verrill.
FIG. 20. — *Phellia arctica* Ver. After Verrill.

55. Height of column (contracted) 18 mm., diameter of oral disk 5 mm.; scapus with rough, thick cuticula; below the middle are several transverse rows of large egg pits
Phellia arctica Ver., A., 30 fathoms (Fig. 20)

SPECIES OF CERIANTHEÆ.

56. Aboral end rounded and provided with a pore; aboral portion of column contained within a secreted tube . . Cerianthus 57

57. Column cylindrical, tapering aborally, length 600 mm. (contracted, 200 mm.), diameter of column near middle, 25 mm.; marginal tentacles (125 or more) 32–38 mm. in length, circumoral tentacles 18 mm. in length
Cerianthus americanus Ver., M., S., shallow water (Fig. 21)

FIG. 21.

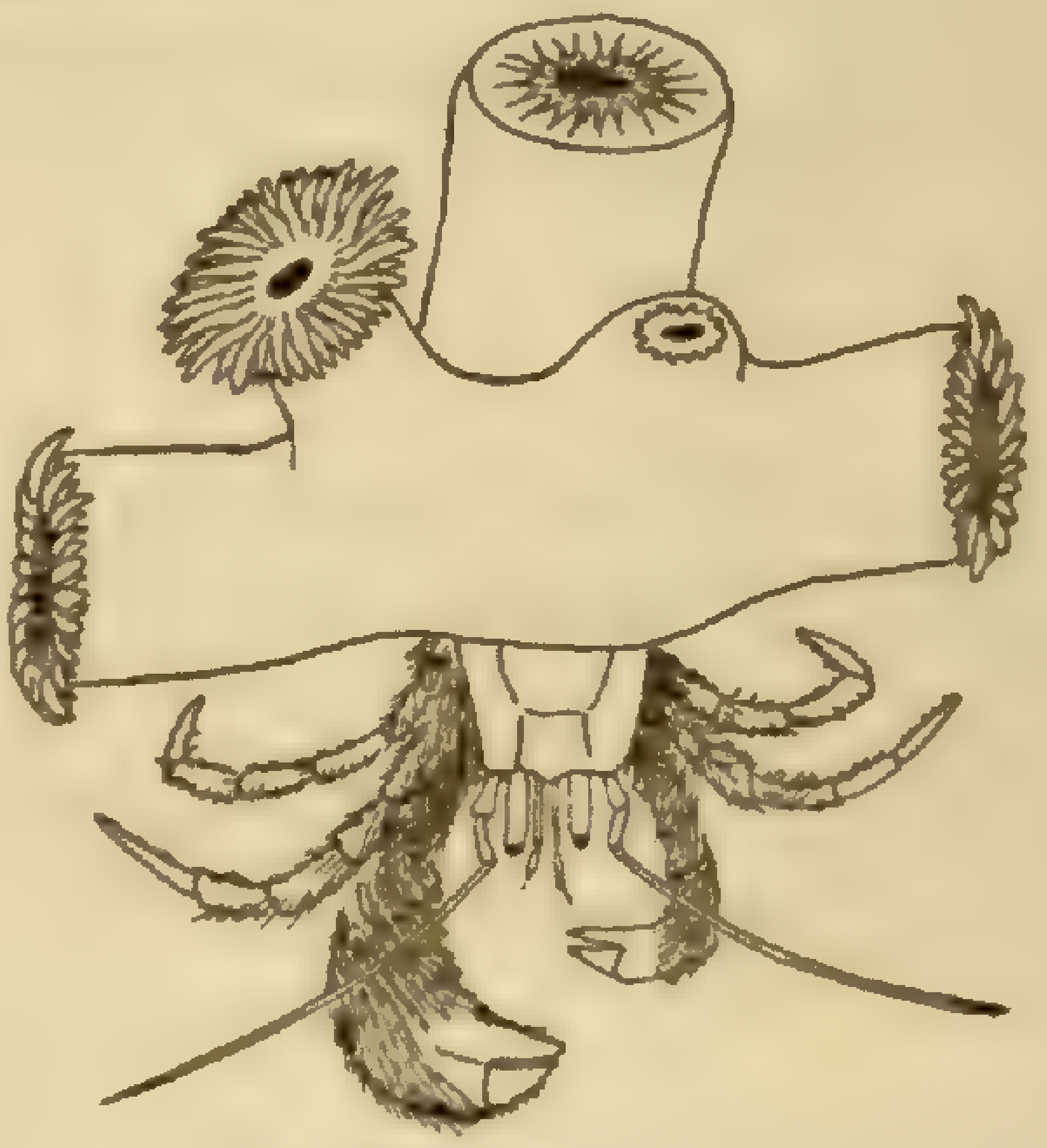


FIG. 22.

FIG. 21. — *Cerianthus americanus* Ver. After McMurrich.
FIG. 22. — *Epizoanthus americanus* Ver. After Verrill.

57. Column cylindrical, tapering aborally, length 450 mm., diameter 40 mm.; tentacles very numerous; marginal tentacles of different lengths, outer ones 25 mm. long, inner ones 56 mm. long; circumoral tentacles 25 mm. long, in several rows
C. borealis Ver., N., M., 7–150 fathoms

SPECIES OF ZOANTHEÆ.

58. Surface of body more or less incrusted with sand grains
Epizoanthus 59

59. Colonies of from three to ten or more polyps growing out of a common flesh; height of polyp about 25 mm.; tentacles thirty-eight or more; attached to stones or to dead snail shells inhabited by hermit crabs (in many instances the shelly material has disappeared, leaving the common flesh of the colony to form an investment for the crab)
Epizoanthus americanus Ver., N., M., 28–466 fathoms (Fig. 22)

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'63 *Journ. Boston Soc. Nat. Hist.* Vol. vii, p. 525.

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'68 *Proc. Essex Inst.* Vol. v, p. 315.
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REVIEWS OF RECENT LITERATURE.

GENERAL BIOLOGY.

Woods Holl Lectures for 1899.[1] — No clearer indication of the drift of affairs at the Marine Biological Laboratory at Woods Holl can be found than that contained in the volume of lectures for the past year. The growing interest in the station as a botanical center is shown in the fact that, while in 1898 no botanical lectures were published, in the past year one-fourth of the lectures are by botanists. D. H. Campbell spoke on the evolutions of the sporophyte in the higher plants; the importance of fossil plants was emphasized by D. P. Penhallow; and D. T. Macdougal discussed some factors in distribution and the significance of mycorrhizas. Animal psychology was represented by two lectures by E. Thorndike, one on instinct, and the other on associative processes in animals, and by a lecture by H. S. Jennings, on the behavior of unicellular organisms. "Some Governing Factors usually neglected in Biological Investigations," by A. Hyatt, and "The Aims of the Quantitative Study of Variation," by C. B. Davenport, were both contributions to the field of general biology. Physiology was represented by A. Mathews's paper on the physiology of secretion and J. Loeb's interesting contribution on the nature of fertilization, while from the experimental standpoint T. H. Morgan's lecture on regeneration is of importance. Cytology, which heretofore has been paramount, was represented by only two papers: "Nuclear Division in Protozoa," by G. N. Calkins, and "The Significance of the Spiral Type of Cleavage," by C. M. Child. Other interesting lectures were one on blind-fishes, by C. H. Eigenmann, and one on the development of color in moths and butterflies, by A. G. Mayer. The series of lectures, taken as a whole, shows an unusually well-balanced development of biological interests. P.

Animal and Plant Colors. — Color in nature has been made the subject of an interesting volume of some 350 pages, by Marion I.

[1] *Biological Lectures* from the Marine Laboratory, Woods Holl, Mass., 1899. Boston, Ginn & Company, 1900. 282 pp.

Newbigin.[1] The introductory portion, which is included in the first two chapters, deals with the well-known distinctions between pigmental and structural colors and a further classification within these two groups. It also contains a brief account of light-producing organisms. Then follows a series of chapters devoted to the consideration of the color phenomena in plants and in the various groups of the animal kingdom, special attention being paid to butterflies and to birds. As a result of this survey, the author states "that it is as yet impossible to give a definite physiological explanation of the origin of pigment; that it is practically impossible to classify pigments in a logical manner; that most of the problems connected with the subject are entirely unsolved." After this general denial of results, except from a simply descriptive standpoint, the author devotes a closing chapter to the theoretic aspects of the subject. This gives in an impartial way the explanations of the origin of different types of coloration as advocated by such Darwinists as Poulton, by such Lamarckians as Cunningham, and by those who, like Wallace, occupy intermediate grounds; Simroth's fanciful conceptions occupy what seems to us an undue amount of space. The Darwinian views are criticised from the standpoint of Piepers's able paper, and the views of the non-Darwinians are dismissed because they imply the inheritance of acquired characters.

The volume shows little originality, but the very fact that the author has no special views of her own to advocate allows her to give the views of others in a more impartial way. The book is concluded with a good list of references, an index of authors, and an index of subjects. It is exceptional in having escaped the hands of the chromo-lithographer or, in fact, those of any illustrator. P.

The Plankton of the Elbe, near Dresden, has been studied by Dr. B. Schorler[2] in collections made at eleven intervals, from April to November, 1898, in the main stream and in three contiguous bays. The current in the Elbe ranges from 40 to 190 cm. per second, and the plankton was less abundant in the main channel than it was in the quieter water of the adjacent bays, thus illustrating Schröder's law that the volume of plankton in a stream is inversely proportional to the rate of the current. In all, 143 species were found, of which

[1] Newbigin, M. I. *Color in Nature, a Study in Biology.* London, J. Murray, 1898. xii + 344 pp.

[2] Schorler, B. Das Plankton der Elbe bei Dresden, *Zeitschr. f. Gewässerkunde,* Bd. iii (1900), pp. 1–27.

88 are plants, and about one-third are reported as common. Like that of the Oder, the Elbe plankton is characterized by the predominance of diatoms, especially in spring and autumn. In the main stream the phytoplankton greatly exceeds the zoöplankton in volume and variety and plays a very important part in the self-purification of the river water. Access of sewage does not have a deleterious effect upon the plankton. Dr. Schorler does not regard the Elbe plankton as autonomous, but dependent for its maintenance upon accessions from adjacent bays and lagoons, and from tributary waters. The littoral fauna and flora also contribute to the potamoplankton. In the still water of the bays an abundant animal plankton of rotifers and crustaceans was found, which reached the unusual volume of 112 c.c. per cubic meter of water.

C. A. K.

ZOÖLOGY.

New Edition of "Wilson's Cell." — The penalty that an author must pay for writing a successful text-book is that of revision, and this penalty has been conscientiously and fully met by Dr. Wilson[1] in the new edition of his text-book on the cell. The first edition was published in 1896 and contained 371 pages and 142 illustrations. The second edition, now before us, contains upwards of a hundred additional pages and nearly fifty new illustrations. Minor changes appear on almost every page, and some sections have been entirely recast. The more striking changes reflect the steady growth of cytological knowledge. Thus, the centrosome, which in the first edition was treated as a permanent organ of the cell, is, in view of the most recent work on both plants and animals, regarded now as of mixed character, in that it sometimes exhibits the peculiarities of a permanent organ by being inherited from cell to cell, and at other times is strictly temporary. The statements as to the finer structure of protoplasm have also been considerably modified. In the first edition Dr. Wilson favored the fibrillar theory, though without denying that other views might contain more or less truth. In the second edition the alveolar theory and even the granular theory have gained sufficiently to be fairly abreast their former rival. This change of

[1] Wilson, E. B. *The Cell in Development and Inheritance.* New York, The Macmillan Company, 1900. Second edition, xxi + 483 pp.

view is presumably largely due to Dr. Wilson's own work, and the opinion now expressed in his book is that the various types of structure assumed for protoplasm by different schools may in reality represent different phases in the functional activity of this substance. So thoroughgoing and complete has been the revision for the new edition that it will form an invaluable aid to every one interested in modern aspects of cytology.

P.

Intracellular Canals in Ganglion Cells. — The system of canals within the protoplasmic substance of ganglion cells, to which Holmgren has recently called attention, has been identified by Bethe[1] in the spinal ganglion cells of the rabbit. That these canals have a wall of their own as contrasted with the protoplasm of the cell in which they lie seems doubtful. They can be traced, however, beyond the limits of the cell, and in such regions show an undoubted wall; but this contains no nuclei, and hence its histological composition is in doubt. No connection between the canals and blood vessels could be demonstrated, the structures in this respect differing from the tubes discovered by Adamkiewicz. The physiological significance of these canals, whether they be lymph spaces or other such structures, is still to be ascertained.

P.

Vertebrate Anatomy. — Professor W. S. Miller[2] has edited and published under one cover four papers on vertebrate anatomy, the work having been done for the most part by students in his laboratory. The first deals with the histology of the lung of Necturus, the second with this animal's vascular system, and the third with its brain. These three contributions are simple descriptive statements of the more obvious facts that they have to deal with, and are not far-reaching in any direction. The fourth paper takes up the question as to whether there are preformed natural openings on the lining of the body cavity of the cat, a question which is answered in the negative. The papers on the whole are not of a high order, and, in fact, it is difficult to justify the publication of the first three. Nor is the editorial work well attended to, as the following sentence

[1] Bethe, A. Einige Bemerkungen über die "intracellulären Kanälchen" der Spinalganglienzellen und die Frage der Ganglienzellenfunction, *Anat. Anzeiger*, Bd. xvii (1900), pp. 304-309.

[2] Miller, W. S. Contributions from the Anatomical Laboratory of the University of Wisconsin, *Bull. Univ. Wis.*, Science Series, vol. ii (1900), pp. 199-245, Pls. III-XV.

shows (p. 203): "The nuclei of these cells do not seem to occupy any one characteristic position, but are found in all parts of the cell."

P.

Elementary Physiology.[1] — This small book consists of a series of outline headings in physiology for schools, with references to standard books where information on the subjects can be had, as well as a set of laboratory exercises in this science. The grade of the work can be judged from the fact that on page 2 ten book references are given, of which six lead the reader to Shepard's *Chemistry* and inform him that "any other good chemistry will answer just as well," and four direct him to the "Dictionary, any unabridged." The laboratory exercises equal the outlines. On page 140 we are instructed to "get from a butcher either the head of some mammal which still has the eyes uninjured or some eyes that have been carefully removed," and, after certain preliminary steps, to pour out the vitreous humor and observe "the yellow spot, or area of acute vision." As an obvious yellow spot is limited among mammals to human beings and monkeys, one is naturally inquisitive about the butcher shops in the neighborhood of the State Normal School of Minnesota. Unpretentious as the book is, one must regret that it departs so far from facts.

P.

Formaldehyde. — The properties of formaldehyde have been made the subject of an interesting communication by Neuville.[2] An historical sketch of its discovery, uses in biology, as well as an account of its method of preparation and its physical and chemical properties, precede a discussion of its action on albuminoids and color compounds. Gelatin, when subjected to its action, is rendered insoluble, though still remaining flexible. This action is not a simple coagulation, but a real chemical action, for, if the solution of formaldehyde used is weak, all traces of this reagent disappears when considerable gelatin is mixed with it. On the other hand, blood serum is less easily coagulated by heat, etc., in the presence of formaldehyde. Its action on pigments is very diverse. The coloring matters of bile and of urine seem unaffected by it, but those which give to organisms their normal colorations are so differently

[1] Cox, U. O. *A Syllabus of Elementary Physiology, with References and Laboratory Exercises.* Mankato, Minn., Free Press Printing Co., 1899. viii + 167 pp.

[2] Neuville, M. H. Sur la formaldéhyde, *Bull. Soc. Philomathique, Paris*, Sér. 9, T. i (1899), pp. 104–121.

affected that no rules can be laid down for its use, though it is certainly less of a decolorizer than alcohol. Its considerable antiseptic and toxic properties are finally described. P.

Jordan and Evermann's Fishes, Part IV.[1] — The last volume of this great work has just been issued. It contains the additional Addenda and the plates illustrating nearly one thousand species of American fishes. This entire work is in one sense a revision of "Synopsis of Fishes of North America" (*Bulletin No. 16*), by Jordan and Gilbert. *Bulletin No. 16*, however, included only the fishes then known to inhabit North America north of the Tropic of Cancer. Aside from the Addenda, it forms one volume of 866 pages and records 1339 species. The Addenda contain 108 more pages, which adds about 160 more species. The volume contains no plates. The present work includes all salt-water fishes which inhabit America north of the equator, and all fresh-water fishes north of the Isthmus of Panama. Aside from the Addenda, the work contains 2744 pages and describes 3127 species of fishes. The Addenda in Vol. III contain 130 pages, and Vol. IV has an additional Addenda of 160 pages. Vol. IV also includes a complete table of contents for all species listed in the four volumes. "From this systematic arrangement it is seen that the fish fauna of North and Middle America, as now understood by the present authors, embraces 3 classes, 30 orders, 225 families, 1113 genera, 325 subgenera, 3263 species, and 133 subspecies." This is by far the most extensive and most useful work ever written on American fishes. It contains descriptions of all the species known from the region which it covers and analytical keys to facilitate identification.

Attention is often called to doubtful species in footnotes, and in many cases the original description is given. This tendency not to place in synonymy doubtful species, when chances are even that a careful study will prove them valid, is to be commended. It will no doubt require a careful study of variation to dispose properly of many doubtful species and many subspecies. It is best to let them stand as first indicated until this sort of study can be made. The next century will witness a great deal of study of the variation of animals, which, with its complement of morphological study, will eventually reduce the work of the classification to a proper basis.

[1] Jordan, D. S., and Evermann, B. W. The Fishes of North and Middle America, *Bull. U. S. Nat. Mus.* (1900), Pt. iv, No. 47, ci + 3137–3313 pp., 392 plates.

The authors will invite some criticism because of their extensive use of genera and subgenera. Any characteristics which will group species must be noticed, but whether or not as much prominence should be given many of these groups by giving generic or subgeneric names will remain as a matter of opinion. If in this respect the authors have gone to one extreme, they have chosen the more scientific one. The retention of common names will prove very useful. The type of each genus is indicated, as is also the locality of the type of each species. The museum in which the type is preserved is also given.

In the mechanical construction of the book we regret that the family and generic names are not at top of the page, as in *Bulletin No. 16;* a useful feature has here certainly been omitted. The authors have done well a great work, and *Bulletin No. 47*, for many years to come, will represent the ideas of our best American ichthyologists concerning the classification of our American fishes.

S. E. Meek.

The Monascidians of the Bremer Expedition. — The report on this group of animals is by Dr. Robert Hartmeyer (*Zool. Jahrb.*, Abth. f. System. Geog. u. Biologie, Bd. XII (1899), pp. 433–520).

In all, eleven species are treated, three of which are new. The genus Dendrodoa, the validity of which has been doubted by several writers, is accepted by the author and a new species added.

It is pointed out that, as between the northern and more southern range of each species, in every case the latter were taken in the greater depths of water.

The author thinks that the distribution of the species confirms the idea of circumpolar range of species. The same writer reported some time ago (*Zool. Anz.*, Bd. XXII (1899), Nr. 590, p. 268) that the two Arctic species in Dendrodoa of the collection retain the larvæ in a brood pouch until a late stage of life. This method of larval protection is not uncommon among compound Ascidians, but is known in only one or two other instances among the simple ones. The author points out that the tendency of Arctic marine animals to thus retain the young for protection is seen in various groups; and that, consequently, the habit in these two species of Monascidians is only in keeping with a general physiological adaptation; that, in all probability, other species will be found to possess the same peculiarity. I may add that I have recently observed the same thing in a species of Ascidia from Alaskan waters. W. E. Ritter.

Relation between Nervous and Glandular Tissue in Ascidians. — It is now fully established that the brain and neural gland in the ascidian embryo develop from a common Anlage. Professor M. M. Metcalf (*Biol. Bull.*, Vol. I, No. 1) has studied the relation of the nerve and duct which spring from the brain and gland, respectively, and run along the median line on the partition wall between the pharynx and cloaca, and finds a closeness of relations there between the two tissues that is quite as remarkable as is the fact of their common origin.

In *Amaroncium constellatum*, for example, a rudimentary duct starts out from the gland, but soon loses its lumen and becomes so intimately united with a strand of cells from the brain that it is impossible to tell whether the common mass should be regarded as coming from brain or gland.

W. E. RITTER.

The Life Cycle of Adelea Ovata, a coccidium parasitic in the digestive epithelium of Lithobius, has been described by Siedlecki.[1] When the sporocysts, which are resistant stages, are taken into the intestine of the host, the two sporozoites are liberated from the cyst and enter the epithelium, where, by a process of endogenous generation, they give rise to two sexually different stages, the microgametocytes and the macrogametes. These pass into the lumen of the intestine, where a smaller microgametocyte attaches itself to a larger macrogamete and undergoes two divisions, producing four microgametes. These two divisions differ in character, the first being a regular division resulting only in a quantitative reduction of the chromatin, while the second is irregular and apparently reduces the number of chromosomes. The nucleus of the macrogamete also rejects a portion of its chromatin. A single microgamete then unites with the macrogamete, and divisions follow which result in the formation of the resistant sporocysts.

C. A. K.

Notes. — In the Prague *Sitzungsberichte* Dr. Mrazek describes the destruction of cysts of the sporozoan Glugea in the spinal cord of Lophius by the phagocytes of the host which press through the walls of the cyst and devour the spores.

The limnetic Peridinidæ of Norway are discussed by Huitfeldt-Kaas in the Christiania *Skrifter*. Five species are reported, of

[1] Siedlecki, M. Étude cytologique et cycle évolutif de Adelea ovata Schneider, *Ann. de l'Inst. Pasteur* (1899), pp. 169–192, Pls. I–III.

which three are new. One of these, *Ceratium curvirostre*, resembles *C. kumaonense*, described by Carter in 1871, from Hindostan. The cosmopolitan *C. hirundinella* reaches its greatest development in Norwegian waters at the maximum summer temperature, in one instance attaining 50,000,000 per square meter of lake surface.

The inaugural address of Rektor Karl Brandt of the University of Kiel reviews the methods, progress, and problems of planktology, with special reference to the productivity of the sea. The poverty of the tropical oceans is correlated with the greater activity of denitrifying organisms in these waters, while the low temperature of the arctic seas hinders this process and greater fertility ensues.

The larval form of *Epischura lacustris*, a peculiar asymmetrical copepod of our Great Lakes, has been found by Professor C. D. Marsh in Green Lake in the winter months. The structure of the male abdomen and fifth feet are described in the *Transactions of the Wisconsin Academy*. The development of the larva indicates but a remote relation to Diaptomus. The asymmetry appears late in the development of the larva.

No. 3 of Vol. IV of the *American Journal of Physiology* contains the following articles : "The Occurrence and Origin of the Xanthine Bases in the Fæces," by W. H. Parker ; "Physiological Studies on Mucine," by Levin ; "On the Reactions of Certain Infusoria to the Electric Current," by R. Pearl ; and "A Plethysmographic Study of the Vascular Conditions during Hypnotic Sleep," by E. C. Walden.

BOTANY.

The Cyclopedia of American Horticulture.[1] — The second volume of this important work, the first volume of which was noticed in the April number of the *American Naturalist*, proves equally good with its predecessor. Several of the larger genera of Cacti, elaborated (as to their garden representatives) by well-known students of the group, are of especial interest to American botanists ; the chapter on the Grape is gratifying to those who hope for the improvement of other American fruits in as successful a manner as has been achieved in grapes ; much of historic interest is to be found under Greenhouses and Horticulture ; and the article on Insects forms an instructive little introduction to entomology. T.

[1] Bailey, L. H., and Miller, W. *Cyclopedia of American Horticulture* (in four volumes), vol. ii, E–M. New York, The Macmillan Company, 1900.

Notes. — Simultaneously with the concluding number of *Erythea* appears the first number of Vol. V of *Zoe*, which, after a suspension of several years, has resumed publication. In its new form *Zoe* is a thin octavo and apparently to be devoted to botany, so that, judging from this first number, it is a pretty close equivalent of the discontinued *Erythea.*

No. 19 of the *Contributions from the Gray Herbarium of Harvard University*, constituting No. 25 of the current volume of the *Proceedings of the American Academy of Arts and Sciences*, is by Mr. M. L. Fernald and deals with Mexican and Central American phanerogams, chiefly Labiatæ and Solanaceæ. Revisions are given of Salvia and Solanum of the subsection Torvaria, as represented in that region. The former comprises 217 species (contrasted with 118 recognized by Bentham in 1848, and 126 recognized by Hemsley in 1887). A very useful addition to the paper is an alphabetical list of collectors, with an indication of the disposal that has been made of their specimens.

In the *Atti del R. Istituto d'Incoraggiamento di Napoli* for 1899 Professor Comes publishes a monographic revision of the genus Nicotiana, illustrated by seven plates.

M. Crépin has a note on a probable hybrid of *Rosa carolina* and *R. nitida* in *Rhodora* for June.

Under the title "Economic Grasses, III," Professor Scribner issues, as *Bulletin No. 20* of the Division of Agrostology of the United States Department of Agriculture, an illustrated synopsis of the tribes and genera of Gramineæ that will prove useful to all students of that important family of plants.

Carex willdenowii and its allies are given comparative treatment by Holm in the *American Journal of Science* for July.

Under the title of "Icones Floræ Japonicæ" the College of Science of the Imperial University of Tokyo is issuing a folio consisting of plates, accompanied by bibliography in Latin or English, and descriptive text in Japanese. The first fascicle, published in February, illustrates *Prunus pseudo-cerasus*, *a spontanea*, and *Isopyrum nipponicum.*

Messrs. Ito and Matsumura have begun the publication of a Tentamen Floræ Lutchuensis in the *Journal of the Science College of the University of Tokyo.*

Professor Stanley Coulter contributes an annotated catologue of the spermatophytes and pteridophytes of Indiana to the twenty-fourth *Annual Report of the Department of Geology and Natural Resources* of that state.

In *La Semaine Horticole* of June 9 M. Rodigas states that in Paris are cultivated not far from 90,000 trees, the average duration of the principal species of which is placed as follows: horse-chestnut, 115 years; sycamore, 61; ailanthus, 54; locust, 42; linden, 24; Paulownia, 14. The mortality among the trees in the center of the city is said to be twice as great as in the suburbs, and the principal causes of their death are given as: (1) dust on the leaves; (2) reverberation of solar rays from buildings; (3) gas, etc., in the soil; (4) injury to trunks and branches; (5) lack of aëration of roots; (6) the use of salt after snow falls in winter.

The *Yearbook of the United States Department of Agriculture* for 1899, recently issued, contains a number of résumés of progress in science as applied to agriculture, by competent writers, which give the volume an unusual interest and value for the teacher's library.

The *Proceedings of the Society for the Promotion of Agricultural Science* for 1899 contains an index to the contents of the publications of that body during its existence that will greatly facilitate reference to the often valuable matter that they contain.

Der Tropenpflanzer for June contains an interesting article on cotton production and manufacture, illustrated by maps and the most effective graphic devices.

The application of photography to scientific illustration finds exemplification in Mr. Woods's paper on Stigmonose, a disease of carnations and other pinks, recently published as *Bulletin No. 19* of the Division of Vegetable Physiology and Pathology of the United States Department of Agriculture. Among other things the sucking apparatus of aphides, fixed *in situ*, is represented in leaf sections, and it is interesting to observe that these creatures afford a practical demonstration of the course of the flow of sap, since their beaks seek the fibro-vascular bundles of the leaves.

A biographical sketch of Edwin Faxon, accompanied by an excellent portrait, appears in *Rhodora* for July.

GEOLOGY.

The Yellowstone National Park.[1] — The final results of detailed geological investigation in the Yellowstone Park by Arnold Hague, geologist in charge of the survey, are to be published in a monograph consisting of several volumes. Part II of the series has been issued, containing descriptive geology of portions of the area and special papers on petrography and paleontology; several of these, notably those chapters by Professor Iddings, have already been printed in abstract, or more fully in annual reports of the survey. The authors of the several chapters are: Arnold Hague on the Mesozoic ridges of the southern part of the park, J. P. Iddings and W. H. Weed on the Gallatin Mountains and the Tetons, Weed on the Snowy Range, Iddings on petrography, the rhyolites, and some description of portions of the Absaroka Range, C. D. Walcott and G. H. Girty on Paleozoic fossils, T. W. Stanton on Mesozoic fossils, and F. H. Knowlton on the fossil flora.

South of the park the Teton Range contains a nucleus of crystalline schists and gneisses overlain by flexed Paleozoic and Mesozoic strata; these were deeply eroded and covered by breccias and rhyolites, the latter forming vast flows, which constitute a large portion of the present Yellowstone plateau. In the Gallatin Mountains, northwest of the park, strata ranging from Cambrian to Cretaceous have been elevated, folded, and faulted, and at the close of the Laramie the rocks were invaded by dikes, sheets, and laccoliths of igneous rock. In comparing the rocks of Electric Peak and Sepulchre Mountain, the former coarsely crystalline and the latter volcanic, in close proximity, Iddings has determined that diorites may be chemically identical with andesites of different mineral composition. Like the Tetons, the Snowy Range, northeast of the park, has an archæan core bordered by sediments dipping toward the lavas.

In the southern part of the park a number of ridges of Cretaceous sandstone occur, with the rhyolites abutting against their upturned flanks. There are here several exposures of dacite or quartz-andesite, apparently older than the rhyolite. A sandstone near the base of Pinyon Peak contains Laramie plants; a conglomerate

[1] Geology of the Yellowstone National Park, *Monograph XXXII, U. S. Geological Survey*, Pt. ii, Descriptive Geology, Petrography, and Paleontology, by Arnold Hague, J. P. Iddings, W. H. Weed, C. D. Walcott, G. H. Girty, T. W. Stanton, and F. H. Knowlton. xvii+791 pp., 121 plates. Washington, 1899.

overlying the Laramie and beneath the earlier volcanics is here conspicuous and is believed to be of Eocene age.

An interesting physiographic feature described by Mr. Hague is the old outlet of Yellowstone Lake, which formerly drained off to the southward by way of Snake River, and sent its waters to the Pacific. The outflow was through Outlet Canyon, south of the lake, and this gorge was so obscured by forest and glacial drift that for many years it was not suspected as being so important a key to the physiography. It is described as a "broad, deep gorge, and throughout a long period of time evidently served as the channel for a rapid, powerful stream carrying a large volume of water. To-day its bottom is a flat, grassy meadow." . . . An old terminal moraine across the bottom of the canyon marks the course of the present continental divide. A mighty change was effected in late geologic times by the damming of the lake to the southward and its overflow through the decomposed rhyolite on the north, so that the whole vast basin was diverted to form Yellowstone River and drain to the Altantic. The Yellowstone canyon and falls are results of this natural accident.

Professor Knowlton's study of the fossil flora, largely collected from the Tertiary tuffs and breccias, is a valuable contribution to paleobotany. Many species new to science are described, and it is shown that the present flora of the park is wholly distinct from that of Tertiary time. "Climatic conditions must have greatly changed. . . . The climate during Tertiary time, as made out by the vegetation, was a temperate or subtemperate one, not unlike that of Virginia at the present time, and the presence of the numerous species of Ficus would indicate that it even bordered on subtropical."

The volume consists of 900 pages of heavy paper, exclusive of plates, and there are 121 plates, in part map folders and thick heliotypes. A book, 12 × 9 inches, of this thickness, is, to say the least, unwieldy, and it seems undesirable to bind together diverse material, by various authors, in such bulky tomes. The margins are unnecessarily wide, and a book of this sort is extremely difficult to handle, and absolutely useless for the geologist in the field. As all the chapters are distinct in authorship, and the sequence is of no especial significance, such a work might much better be bound in a number of smaller volumes by separate authors.

The microphotographs by Iddings are of unusual excellence, and most of the illustrations are good. The reconstruction of geologic cross-sections in the air (Pls. V, XXXII), for heights of 10,000 feet,

is unwarranted by the facts cited or actual sections shown. Illustration of the descriptive geology would be improved with more diagrammatic figures in the text. There is a prejudice among scientists against text-figures in monographs; it seems to the writer that brevity and precision are the first requirements of a modern scientific work, and sometimes a text-figure will save referring to a remote plate, or reading a page of otherwise obscure statement.

T. A. J., JR.

Maryland Weather Service.[1] — If the plans of the Maryland Weather Service and Geological Survey are carried out to a finish, that state will in a few years have the most complete record of natural resources ever made for a single area. The Weather Service proposes to investigate land forms, weather, water, climate, soil, forestry, crops, fauna, and flora; the Geological Survey is studying earth physics, rocks, and minerals. Both organizations are under the efficient management of Professor William Bullock Clark, supported by state funds and by a corps of scientific assistants picked from Johns Hopkins University.

The first volume of the Maryland Weather Service is issued in the same size and style as the Geological Survey, with lavish illustration in the form of maps, charts, half-tones, heliotypes, and colored plates. The colored cloud pictures of the Hydrographic Office are reproduced. In the introduction Professor Clark states the plan and organization of the service. Cleveland Abbe, Jr., has a chapter on the physiography of the state. Meteorology is treated by Cleveland Abbe, of the U. S. Weather Bureau, F. J. Walz, and O. L. Fassig. The same thorough reconnoissance of the field is shown in this volume as in the early volumes of the Geological Survey. Professor Abbe's chapter on Aims and Methods of Meteorological Work is a complete statement of modern methods of studying the weather, with illustrations of all the instruments used. Other chapters are historical, statistical, and bibliographical. T. A. J., JR.

Experimental Geology.[2] — The course of public lectures given by M. Stanislas Meunier in the Natural History Museum of the Jardin des Plantes in 1898 has been published in a small volume in popular form. The work is divided into two parts; the first deals with experimental imitation of surface processes in geology, denudation,

[1] *Maryland Weather Service*, vol. i. Johns Hopkins Press, 1899.

[2] Meunier, Stanislas. *La géologie expérimentale*. Paris, 1899.

and sedimentation; the second with the chemical and mechanical processes of the earth's interior. The book is illustrated with fifty-six text-figures, mostly in illustration of apparatus now exhibited in the museum.

The experiments described are those which have been carried on in the author's laboratory, as stated in the preface; this being the case, it is unfortunate that the account of apparatus and method is so brief that it would frequently be impossible to reproduce an experiment from the description given. The arrangement of the book is geological, but the text deals almost wholly with laboratory experiments; the geological application is not always clear, and in other cases the demonstration seems self-evident. Thus, particles of quartz are placed on a marble slab under a stretched elastic band, a weight is placed above, and the elastic slowly released. "Striations are produced comparable to those of glaciers." The conclusion is stated that glaciers cannot move as they do without eroding their beds. Again, Élie de Beaumont is quoted as stating that deltas are characteristic and distinctive of the present epoch; M. Meunier is convinced, after experimental study of deltas, that analogous structures have always existed since sedimentation began — a conclusion not likely to be disputed. This elementary treatment of the subject, however, is perhaps justified by the popular quality of the work; the experiments are illustrative rather than conclusive.

T. A. J., Jr.

Maryland Geological Survey.[1] — The third volume of the *Maryland Geological Survey* has been promptly issued and is as thorough and well executed as the earlier volumes. The subject is highway investigation; Professor Clark, state geologist, contributes two chapters on organization and on the relation of the geography, geology, and climate of the state to road building. Excellent physiographic, geologic, and meteorologic maps of the state are presented, and microphotographs showing the structure of the principal rocks which may be used as road metals. St. G. L. Sioussat gives an interesting historical chapter on the development and influence of highway legislation in Maryland, and A. N. Johnson describes exhaustively the present condition of the state highways and methods of road construction. The last three chapters are by Professor Reid, on experimental tests, administration, and highway economy. The

[1] *Maryland Geological Survey*, vol. iii. Johns Hopkins Press, 1899. 461 pp., 35 plates.

volume is thoroughly indexed, and in an appendix are printed the laws of Maryland relating to highways. In this volume, as in the earlier ones, the wealth of illustration is an especially marked feature. Separate colored maps of every county show the different kinds of roads and the distribution of rocks available for road building. The chapters on construction, tests, and administration — about one-half the book — are a complete summary of modern road-making methods and have a wide interest outside of the state. The bibliographies are very complete, and the method of road administration of all the states of the Union and many foreign countries is concisely summarized. If publication by the state of an attractive book of instructions tends to produce good roads, Maryland, in this respect, is far in advance of other states.

T. A. J., Jr.

PUBLICATIONS RECEIVED.

(Regular exchanges are not included.)

Bessey, C. E. The Modern Conception of the Structure and Classification of Diatoms, with a Revision of the Tribes and a Rearrangement of the North American Genera. *Trans. Amer. Micr. Soc.* Vol. xxi, pp. 61–86, Pl. V. — Beyer, Geo. E. Louisiana Herpetology, with a Check List of the Batrachians and Reptiles of the State and the Avifauna of Louisiana, with an Annotated List of the Birds of the State. New Orleans, 1900. 45 pp. Reprinted from *Proc. La. Soc. Nat.* — Bruner, H. L. On the Heart of Lungless Salamanders. *Journ. of Morph.* Vol. xvi, No. 2, pp. 323–353, Pl. XV. — Call, R. E. A Descriptive Illustrated Catalogue of the Mollusca of Indiana. *24th Ann. Rep. Dept. Geol.*, etc., *Indiana.* pp. 337–535, 78 plates. — Currie, Rolla P. A New Bird of Paradise. *Proc. U. S. Nat. Mus.* Vol. xxii, No. 1204, pp. 497–499, Pl. XVII. — Jordan, D. S., and Evermann, B. W. The Fishes of North and Middle America, Pt. iv. *Bull. U. S. Nat. Mus.* No. 47, ci + 3137–3313 pp., 392 plates. — Macoun, J. Catalogue of Canadian Birds. Pt. i, Water Birds, Gallinaceous Birds, and Pigeons. *Geol. Survey Canada.* Ottawa, 1900. 218 pp. — McCalley, Henry. Report on the Warrior Coal Basin. *Geol. Survey Alabama.* Jacksonville, Fla., Vance Printing Company, 327 pp., map and figs. — Merrill, G. P., and Stokes, H. N. A New Stony Meteorite from Allegan, Michigan, and a New Iron Meteorite from Mart, Texas. Vol. ii, pp. 41–68. — Miller, G. S., Jr. The Giant Squirrels of Burmah and the Malay Peninsula. Vol. ii, pp. 69–77. — Miller, G. S., Jr., Descriptions of Two New Squirrels from Tuong, Lower Siam. *Proc. Washington Acad. Sci.* Vol. ii, pp. 79–81 — Miller, G. S., Jr. Preliminary Revision of the European Red-backed Mice. *Proc. Washington Acad. Sci.* Vol. ii, pp. 83–109. — Osborn, H. F. Correlation between Tertiary Mammal Horizons of Europe and America, etc. *Ann. N. Y. Acad. Sci.* Vol. xiii, No. 1, pp. 1–72. — Rankin, W. M. The Crustacea of the Bermuda Islands. *Ann. N. Y. Acad. Sci.* Vol. xii, No. 12, pp. 521–548, Pl. XVII. — Smith, Frank. Notes on Species of North-American Oligochæta. IV. On a New Lumbricid Genus from Florida, etc. *Bull. Illinois State Lab. Nat. Hist.* Vol. v, pp. 459–478, Pl. XLI. — Smith, John B. A Hundred New Moths of the Family Noctuidæ. *Proc. U. S. Nat. Mus.* Vol. xxii, pp. 413–495. — Trelease, Wm. Some Twentieth-Century Problems. *Science.* Vol. xii, pp. 48–62.

Bulletin Johns Hopkins Hospital. Vol. xi, Nos. 112, 113. July–August. — *Journal Cincinnati Society of Natural History.* Vol. xix, No. 6. — *Insect World, The.* Vol. iv, No. 6. June. — *Science Gossip.* Vol. vii, No. 74. July.

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CONTENTS

			PAGE
I.	**Reconsideration of the Evidence for a Common Dinosaur-Avian Stem in the Permian**	**Professor H. F. OSBORN**	777
II.	**The Gall of the Monterey Pine**	**W. A. CANNON**	801
III.	**Note on Distomum Arcanum (N. Sp.) in American Frogs**	**Professor W. S. NICKERSON**	811
IV.	**Instinct or Reason?**	**G. W. and E. G. PECKHAM**	817
V.	**Editorial Comment:** Doubtful Economy, Frazer's Life of Cope, The Biological Bulletin		819
VI.	**Reviews of Recent Literature:** ***Psychology,*** Individual Psychophysiology of the Crayfish, The Problem of Innate Ideas, Empirical Teleology—***Zoölogy,*** The Effect of Staleness of the Sex-Cells upon Development, Protozoan Studies, The Aleurodidæ, Scientific Results of H. M. S. "Thetis," The Temple Primers, The Biological Bulletin, Notes—***Botany,*** Text-Book of Botany, Notes—***Paleontology,*** Fossil Cephalopods in the Timan, Russian Carboniferous Cephalopods		821, 823, 828, 830
VII.	**News**		832
VIII.	**Publications Received**		834

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RECONSIDERATION OF THE EVIDENCE FOR A COMMON DINOSAUR-AVIAN STEM IN THE PERMIAN.

DINOSAUR CONTRIBUTIONS, NO. 4.[1]

HENRY FAIRFIELD OSBORN.

The relation of dinosaurs to birds has been one of the most attractive problems of comparative anatomy during the thirty-seven years which have elapsed since Gegenbaur's observation that the tibiotarsus of Compsognathus, one of the smallest carnivorous dinosaurs, closely resembles that of the bird.

Since a number of new avian resemblances have recently been discovered among dinosaurs, it seems important to reconsider this much debated problem.

I. Avian Resemblances in Carnivorous Bipedal Dinosaurs.

We owe to Fürbringer ('**88**, p. 1592) a valuable historical summary of the literature and progress of opinion. The recognition of avian characters among dinosaurs has been generally

[1] Presented before the American Association for the Advancement of Science, Section Zoölogy, June 27, 1900.

Fig. 1. — Ankle joint of dinosaurs and birds, tibiotarsus. *A*, pigeon (Columba), after Baur; *B*, carnivorous dinosaur (Megalosaurus), after Cuvier; *C*, the same, back view; *D*, young ostrich (Struthio), after Baur; *E*, the same, from the side; *F*, Ornithotarsus, from Baur, after Cope.

attributed to Cope and Huxley; but it appears that Gegenbaur enjoys the priority; for, in 1864 (**'64**), he pointed out that Compsognathus in the structure of its tarsus presents a transition stage between birds and reptiles, or a species of double relationship, which in fact pervades the entire skeleton. Cope (**'66**, p. 317; **'67**, pp. 234, 235; **'69**, p. 123) made a similar observation in Lælaps, the great carnivorous Upper Cretaceous dinosaur, and considered the carnivorous dinosaurs in general as intermediate in position between reptiles and birds, adding to the list of avian characters the elongation of the vertebræ of the neck and the very light construction of the arches of the skull.

Unaware of Cope's observations, Huxley's attention was directed to the matter by Professor Phillips's collection of carnivorous dinosaur (Megalosaurus) remains in the Oxford Museum; fresh from his memoir on the classification of birds, published in 1867, his eye was

keen for avian resemblances, and he at once noted that the ilium of Megalosaurus was bird-like. In fact, Phillips had previously noted the resemblance of this bone to that of Apteryx.

Stimulated to further comparison, Huxley ('69, pp. 15 f.) observed other avian features, *viz.*, that the ischium of dinosaurs extends back parallel with the ilium; that the pre-acetabular process, or pubic peduncle of the ilium, extends further downward than the post-acetabular, or ischial peduncle; that the acetabulum itself is partly open; that the limb bones are distinctly tubular; that the scapulo-coracoid elements are anchylosed together; that the sacrum is partly ornithic, partly reptilian; that the femur is vertical to the body, its head extending outward into the acetabulum; that the tibia possesses a prominent procnemial crest; that the astragalus embraces the lower end of the tibia. Huxley concluded ('68) "there could be no doubt that the hind quarters of Dinosauria wonderfully approached

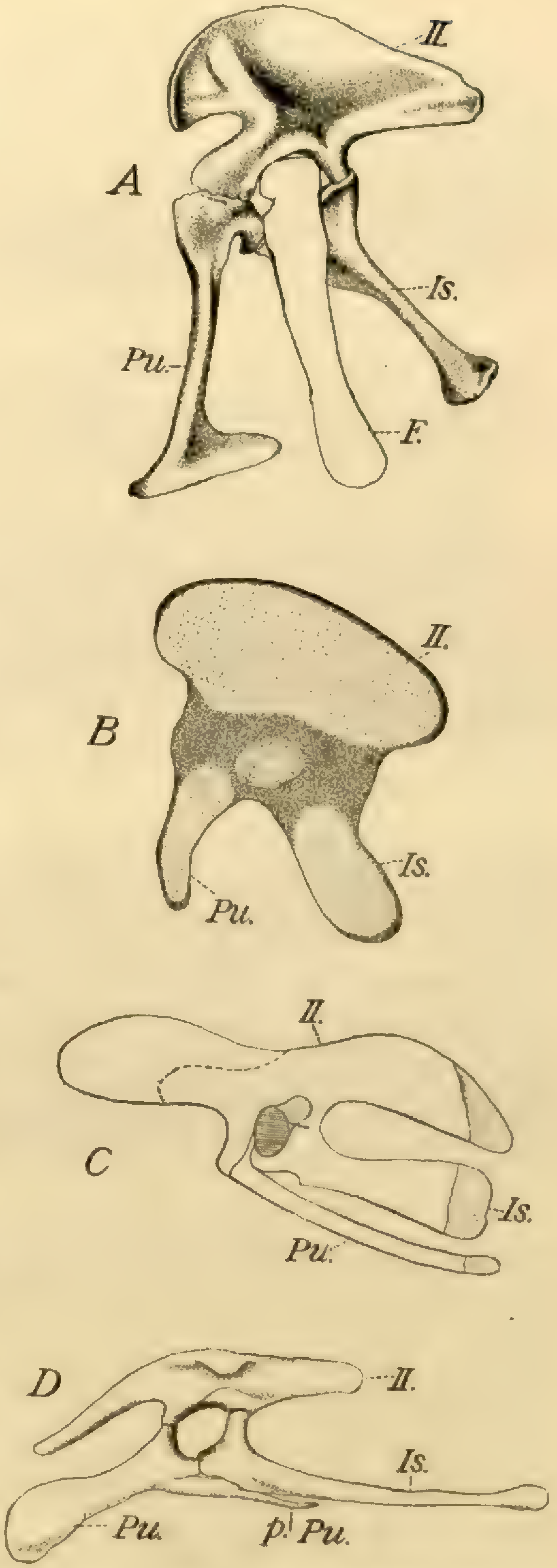


Fig. 2. — Pelvic arch of left side, dinosaurs and birds. *A*, carnivorous dinosaur (Allosaurus), triradiate type, after Marsh; *B*, embryonic bird (Larus), triradiate type, after Mehnert; *C*, adult bird, pubis rotated backwards, after Gegenbaur; *D*, iguanodont dinosaur, vestigial postpubis, quadri-radiate type, after Marsh.

those of birds in their general structure, and, therefore, that these extinct reptiles were more closely allied to birds than any which now lived." He did not commit himself to the theory of direct ancestry, however, as shown in the following passage: "It may be regarded as certain that we have no knowledge of the animals which linked reptiles and birds genetically, and that the Dinosauria, with Compsognathus, Archæopteryx, and the struthious birds only help us to form a reasonable conception of what these intermediate forms may have been." In one important anatomical point Huxley was in error, since he believed that the pubis of dinosaurs, like that of birds, was directed backwards; whereas we now know that in all dinosaurs the pubis is directed forwards, like that of other reptiles. Huxley's ideas culminated in his proposal of the group Ornithoscelida, or "bird-limbed" reptiles, to embrace two suborders, Dinosauria and Compsognatha. The latest expression of Huxley's opinion is found in his paper on the "Respiratory Organs of Apteryx" (**'82**, p. 569): "Thus, notwithstanding all the points of difference, there is a fundamental resemblance between the respiratory organs of birds and those of crocodiles *pointing to some common form* (*doubtless exemplified by some of the extinct Dinosauria*), *of which both are modifications*." (The italics are our own.) Huxley's final view, therefore, was that birds sprang from some primitive and unknown type of dinosaur.

The conception of direct descent of birds from dinosaurs gained ground until it reached the force of positive theory in the writings of Hoernes, and especially of Marsh, as seen in the following paragraph (**'77**, p. 228): "It is now generally admitted by biologists who have made a study of the vertebrates that birds have come down to us through the dinosaurs, and the close affinity of the latter with recent struthious birds will hardly be questioned." Subsequently, however, Marsh (**'80**, p. 188) pointed out that the absence of feathers in dinosaurs and pterosaurs and the presence of a free quadrate in birds rendered it probable that birds descended not from dinosaurs but from a more ancient sauropsid form.

II. Rise of the Theory of Homoplasy.

The theory of direct descent was more or less strongly supported by many anatomists, but there were also many dissenters. Seeley (Fürbringer, '**88**, p. 1595) pointed out with truth that the direct descent theory rested upon resemblances of certain bones of the pelvis and posterior extremities which are found only in certain genera and are not characteristic of the whole group.

Vogt also advocated the homoplastic view. Their opinions ('**79**) were given by Seeley ('**81**) as follows :

"'All the characters whereon are based the claim of dinosaurs to be regarded as the ancestors of birds are only related to the power of keeping an upright position upon the hind feet.'

"Vogt believes that certain dinosaurs were leaping or perching animals, and infers that the avian characters of the pelvis and hind limbs thus came to be evolved from community of habit with birds. He is, however, not indisposed to see in dinosaurs possible parents of the ratites; while the Archæopteryx would be the ancestor of the birds that fly."

In 1882 Dollo also ('**82**, '**83**) advanced the more modern idea that the resemblances in the pelvis and hind limbs might as well be considered adaptive as genetic. Baur, however ('**83**, pp. 417 f.; '**85** (2), pp. 446 f.), held firmly to the idea of direct descent, singularly enough, not through the carnivorous dinosaurs, but through the herbivorous iguanodont types. Dames, in opposition to Baur ('**84**), concluded with Vogt, Seeley, and Dollo that the resemblances were due to adaptation, and that the direct ancestors of the birds could not be designated. A still more conservative view, that the resemblances were altogether due to adaptation and not at all indicative of genetic descent, was taken by Richard Owen, by W. K. Parker ('**87**), by Cleland ('**87**), and by Mehnert ('**88**). In the mean time, however, Owen, Cope, Mivart, Wiedersheim, had more or less strongly advocated the theory of the derivation of the carinate birds from the pterosaurs. Thus arose the extreme theory of Mivart ('**81**) that the carinate birds sprang from pterosaurs,

and the ratite birds from dinosaurs. This was supported by Wiedersheim ('**86**).

As a result of his own detailed review and comparison, Fürbringer in his great monograph upon birds ('**88**, p. 1624) concludes that the direct descent of birds from any known type of Dinosauria is excluded; that the birds are monophyletic; that the resemblances between dinosaurs and birds are all "convergence-analogies" and "parallels" due to relationship of the "middle grade"; more definitely ('**88**, p. 1630), he regards Dinosauria, Crocodilia, and Lacertilia in the order named as the nearest relatives of birds, and believes that the stem of the birds is to be sought in a common sauropsidan ancestor lying between the Dinosauria, the Crocodilia, and the Lacertilia; that this stem, as Marsh had already supposed, is to be found in the last division of the Palæozoic, namely, the Permian; here occurred the first differentiation of fine sauropsidan scales into feathers.

The problem thus presents itself now in three forms: (1) are birds directly descended from primitive dinosaurs? (2) have birds and dinosaurs originated from a common stock? (3) are the remarkable resemblances between these two groups entirely due to parallelism or homoplasy?

Before discussing this triple problem we may continue with the subject of the resemblances and differences, or positive and negative evidence.

III. Additional Avian Resemblances in Bipedal Dinosaurs.

Cervical Vertebral Formula. — Fürbringer ('**88**) observes that the cervical + cervico-dorsal vertebræ of birds vary from ten to eleven (Archæopteryx) to twenty to twenty-five in the larger, long-necked forms, indicating that the number of vertebræ is distinctively an adaptive character. More in detail, we may give the avian formulæ as follows:

VERTEBRAL FORMULÆ OF BIRDS.[1]

	Cervicals (with Coalesced Ribs).	Cervico-Dorsals (with Ribs not attached to Sternum).	Dorsals (with Ribs partly attached to Sternum).	Total Number of Cervico-Dorsals and Dorsals.	Total Number of Presacrals or Cervicals, Cervico-Dorsals, and Dorsals.	Sacrals (including Pelvic Vertebræ).	Caudals.
Archæopteryx[2]	10, 11	—	—	11 or 12	21 ?	5, 6	20 or 21
Apteryx	16	1, 2	7, 8	8–10	24–26	—	—
Dromæus	20, 21	2–4	5–7	7–11	27–32	—	—
Struthio	20	2, 3	5	7, 8	27, 28	—	—
Hesperornis[3]	17	—	—	—	23	14	12
Anser cinereus	18	2	4	6	24	—	—
Cygnus olor	23	2	4, 5	6, 7	29, 30	—	—
Most Passeres	14	2, 3	5	7, 8	21, 22	—	—

From this table can be drawn the general conclusion, positive or favorable to the common dinosaur-avian stem theory, that primitive birds had numerous cervicals, few dorsals, and numerous caudals.

Pubis of Birds.—An important negative contribution to this problem is that upon the pubis by Mehnert ('**88**), who shows that the pubis of birds in the earliest stages of development is directed forwards, like that of dinosaurs and other reptiles, and is *secondarily* shifted backwards, parallel with the ischium; that the *processus ileopectineus*, rising mainly from the ilium, is a secondary structure, exclusively characteristic of birds, which has no homology with the falsely called prepubis of dinosaurs; thus the various comparisons of the bird and dinosaur pelvis by Huxley and others lose one of their strongest supports. The primitive (or embryonic) bird pelvis, however, is triradiate and resembles that of the primitive carnivorous dinosaurs. The secondary, or adaptive, bird pelvis is totally different from that of any dinosaur. This militates against the theory of the derivation of birds from any specialized dinosaurs, such as the Iguanodontia or Megalosauria, but not against the theory of a common dinosaur-avian stem.

[1] Mainly from Newton, '**93**–'**96**, p. 849.
[2] Fürbringer, '**88**. [3] Marsh, '**80**.

Musculature of Leg. — Dollo ('83, 2) adds an extremely interesting resemblance in his comparison of the attachment of the muscles connecting the back of the femur with the ischium and with the caudal vertebræ in birds and in Iguanodon; he shows that the so-called "third trochanter" of birds and dinosaurs, to which the name "fourth trochanter" should be

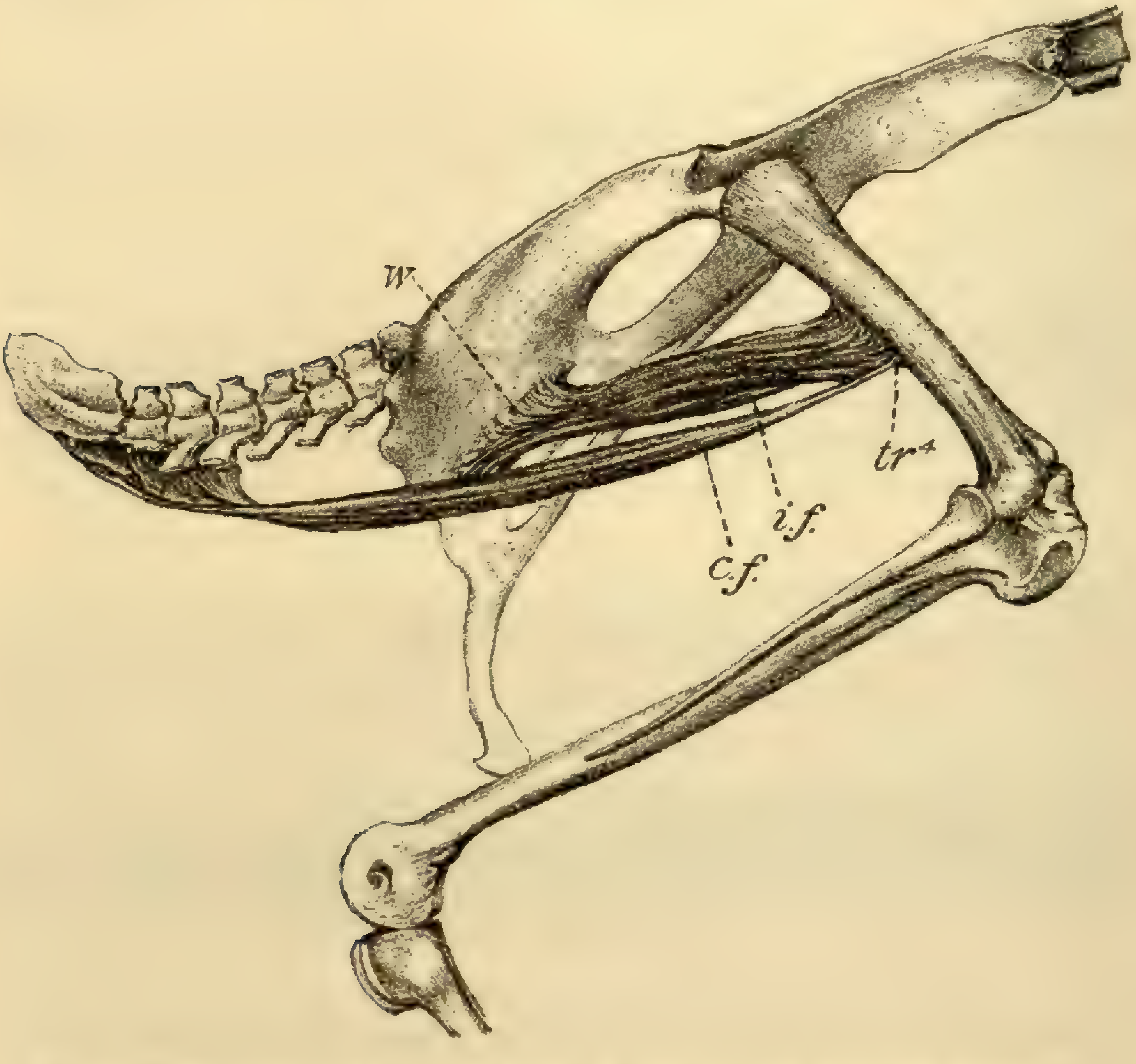


FIG. 3.—Right hind limb of duck (Anas boschas), showing, *tr*4, the supposed 4th trochanter; *i.f.*, ischio-femoral; *c.f.*, caudo-femoral muscles. After Dollo.

applied, is actually a process quite distinct from the "third trochanter" of mammals, that its function is especially for the insertion of the "ischio-femoral" muscle and for the origin of the "caudo-femoral" muscle; he concludes that the femur of Iguanodon is constructed upon the bird and not upon the reptilian type, and, as a corollary of this, that the extrinsic musculature of the tail in Iguanodon presented close resemblances to the corresponding musculature in the bird. As

shown in Fig. 3 there are two muscles at the back of the femur, the larger of which, or "ischio-femoral," passes from the crest of the fourth trochanter back to the ischium; while the more slender "caudo-femoral" passes from the apex of the fourth trochanter back to the caudals and causes the sudden lateral movements of the tail, so characteristic of the duck. The pronounced development of this character in Iguanodon indicates a very powerful "caudo-femoral" muscle in this type. Further, Dollo observes that Hesperornis, with its well-developed tail, presents a condition of the fourth trochanter intermediate between the avian and dinosaurian types.

Fig. 4.—Carnivorous dinosaur (Allosaurus), right hind limb, × $\frac{1}{16}$. After Osborn.

Returning to the carnivorous bipedal dinosaurs, Osborn ('99 (2), p. 163) described the complete hand and foot of Megalosaurus from the famous Bone Cabin Quarry. Of greatest interest is the first digit, or hallux, not before described; proximally the metatarsal of this toe (I) persists and fits into a shallow groove of metatarsal II; the

shaft is, however, entirely interrupted in the middle portion; distally it is fitted to the rounder posterior portion of the shaft of metatarsal II, demonstrating that it was directed inward like the small hallux of Apteryx; unlike this bird, however,

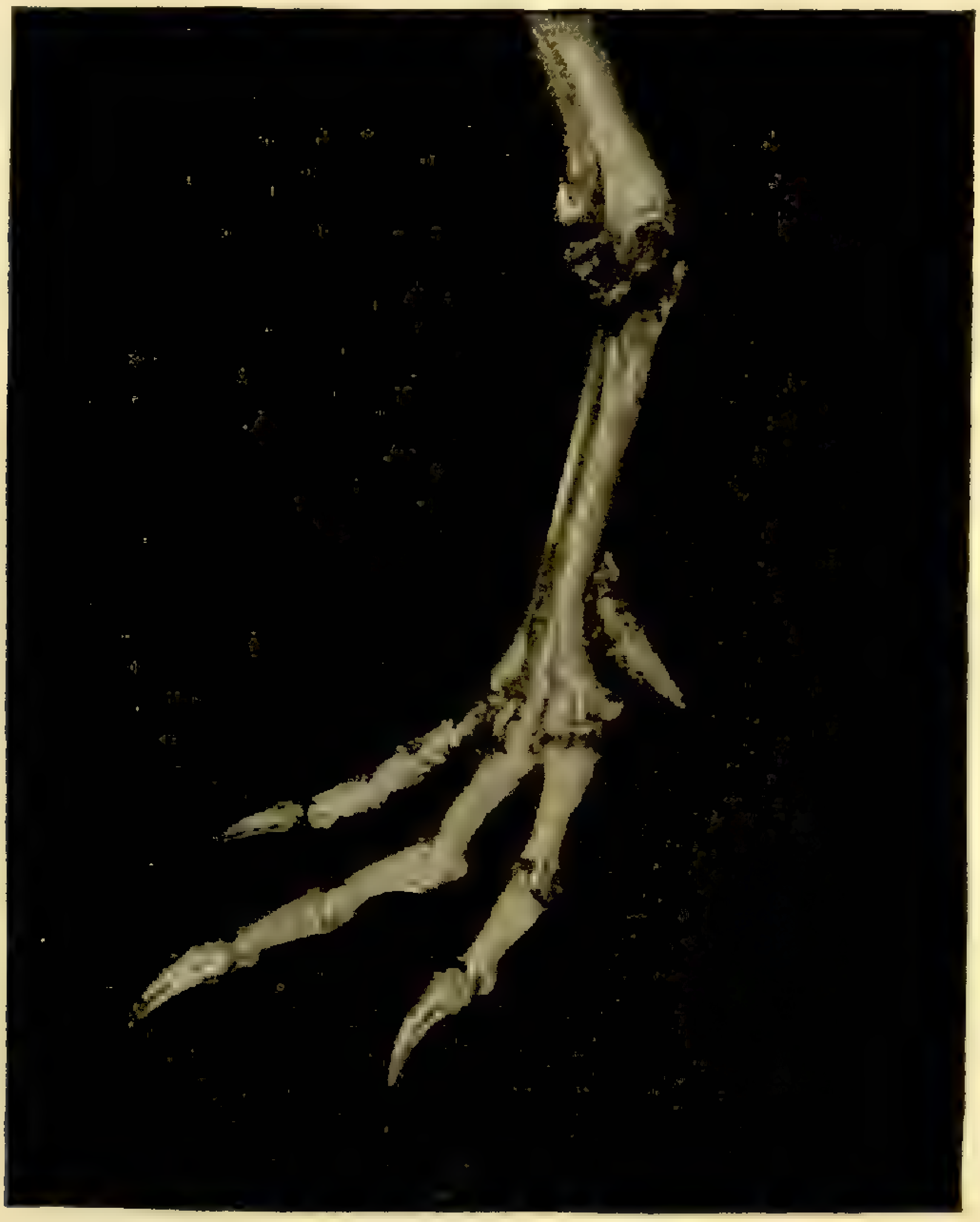


FIG. 5.—Hind foot of bird (Apteryx). Internal view of right tibiotarsus and pes. After Osborn.

Megalosaurus possessed a complete and functional phalanx and claw upon the hallux, which undoubtedly were of service in grasping, as in carnivorous birds.

IV. AVIAN RESEMBLANCES IN QUADRUPEDAL DINOSAURS.

It will be noted that all the resemblances above recorded relate exclusively to the bipedal bird-footed carnivorous and herbivorous dinosaurs, namely, to the Megalosauria and Iguanodontia. The resemblances pointed out below refer to the entirely distinct group of Cetiosauria or Sauropoda, which, in contrast, are quadrupedal and reptile-footed.

In describing Camarasaurus, Osborn ('98, p. 220) directed attention to the resemblance between the cervicals and anterior

"cervico-dorsals" of the Sauropoda and those of the emeu (Dromæus), as follows: "The long neck, similar in structure and almost as flexible as that of an emeu (Dromæus), could thus pass through a prodigious arc in the search for food, either under or above water. The neck motion partly involved the anterior non-spine-bearing dorsals (vertebræ with free ribs, equivalent to the 'cervico-dorsals' of birds), as in Dromæus, behind which the comparatively inflexible, large, spine-bearing dorsals rose to maximum height in the sacrum for the inser-

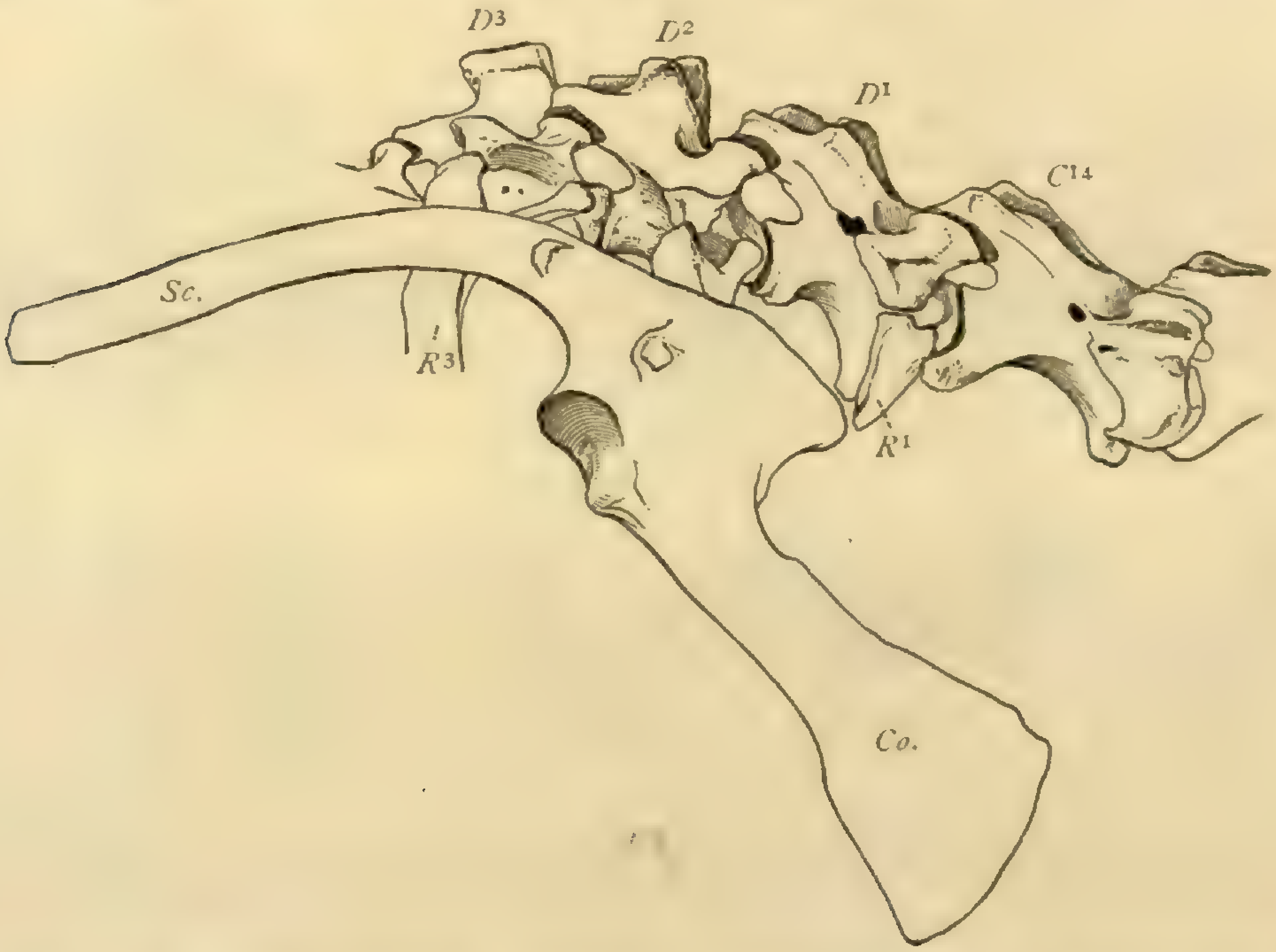


FIG. 6. — Neck of bird (Dromæus). Cervicals 13–14 and cervico-dorsals 1–2 entirely lacking median spines; dorsal 3 with a large blunt median spine. After Osborn.

tion of the *ligamentum nuchæ* and elevator muscles." . . . The importance of such an hypothesis of function will appear in the following description and discussion, and it applies to all the Cetiosauria, namely, to the Morosaurus and Diplodocus types as well, which, so far as known, *are uniform with the camarasaur type in the peculiar bird-like arrangement of the posterior cervicals and anterior dorsals.* (See Fig. 7.)

Again, in the description of Diplodocus, Osborn ('**99** (1), p. 200) pointed out the resemblances in the relations of the posterior ribs to those of Apteryx. Two features were brought out, namely: two of the ribs actually underlie the anterior

border of the ilium, both in Diplodocus and Apteryx ; the last dorsal vertebra of Diplodocus coalesces with the superior border of the ilium by a bar, which may be considered either a metamorphosed rib or an expansion of the metapophysial lamina : if this is a rib, Diplodocus presents a condition analogous to that in Struthio, in which the last vertebra and rib, technically known as a "pelvic vertebra," is all but united with the ilium. (See Figs. 8 and 9.)

Dorsal Vertebral Formula. — The latest contribution to this subject results from the explorations of 1899 in the dinosaur beds of Wyoming. Holland (**1900**, p. 817) shows from the explorations of

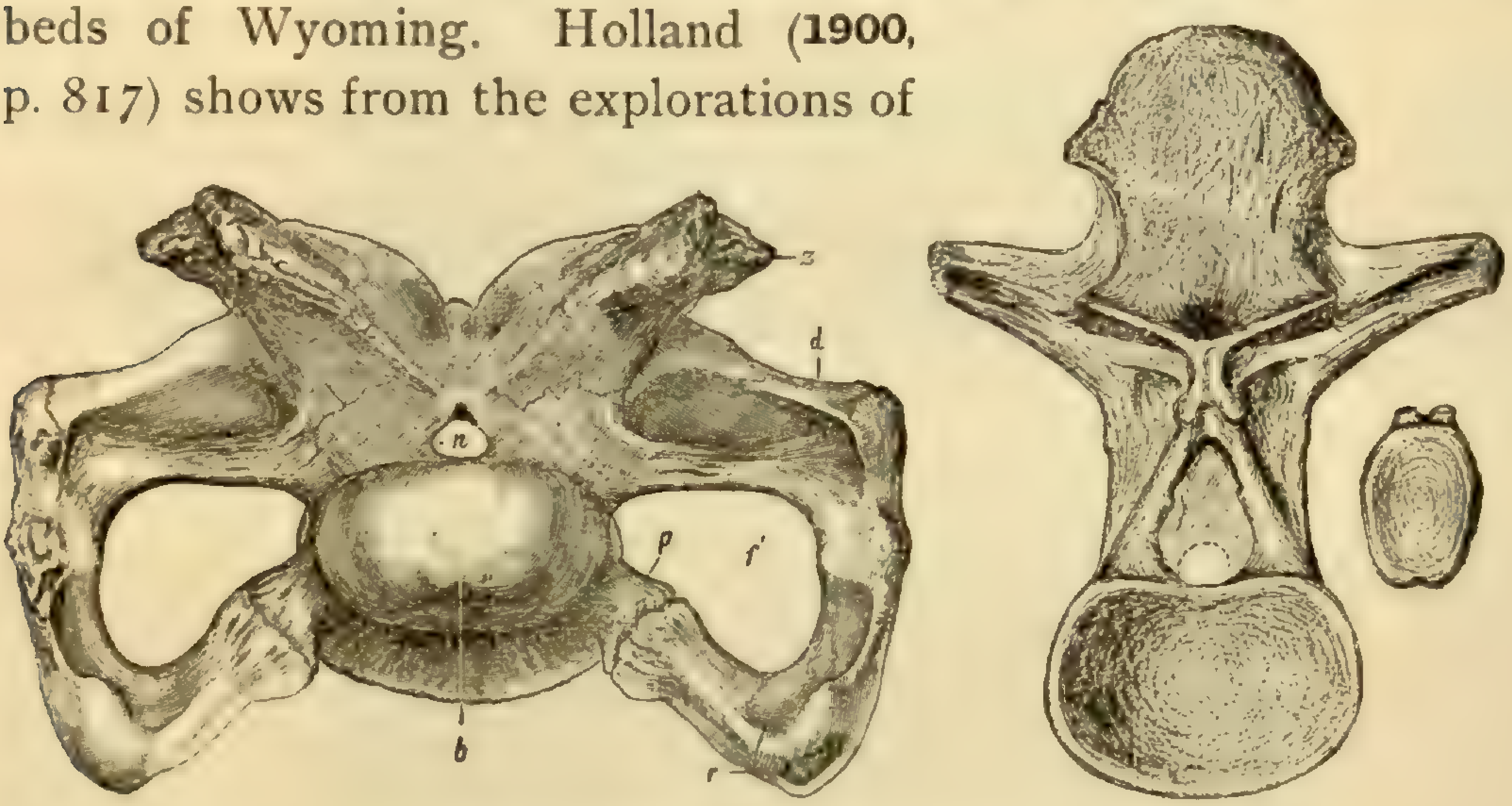


Fig. 7. { Brontosaurus. Posterior cervical, lacking median spine. After Marsh. / Camarasaurus. Anterior dorsal vertebra, with blunt median spine. After Cope.

the Carnegie Museum in the Jurassic of Wyoming that the number of dorsal vertebræ in Diplodocus has been overestimated hitherto by Osborn ; that this animal possesses in fact only ten dorsal vertebræ, the entire vertebral formula being estimated as follows :

Cervicals	at least	13
Dorsals		10
Sacrals		4
Caudals		32–35

Contemporaneous with this discovery is that of the American Museum party, that the dorsal vertebræ of Morosaurus also number *ten*.

Thus, in two of the largest Cetiosauria or Sauropoda we have an extremely short back, resembling the short back of birds, also an extremely long flexible neck, a very rigid attachment between the sacrum and ilium, correlated with the power of *temporarily raising the entire presacral portion* of the body.

The significance of these avian resemblances in the neck and trunk of these gigantic dinosaurs is rather homoplastic than genetic, for the peculiar paired cervical and cervico-dorsal spines, the posterior abdominal ribs, the lengthened pre-acetabular iliac bar, correlated with certain feeding motions, are bird-like structures mingled with other non-bird-like structures too numerous to mention. So also with the resemblances among the bipedal dinosaurs, in which the *presacral portion of the body is permanently raised,* bird-like and non-bird-like structures appear in close propinquity.

The main avian character pervading all Dinosauria is the one originally observed by Gegenbaur, namely, the close junction of the astragalus with the tibia or tendency to form a tibio-tarsus. However, where there is so much smoke there may be some fire, and we may now proceed to look into the probability of the existence of a primitive bipedal dinosaur-avian ancestor.

V. The Clawed Quadrupedal Ancestry of Birds.

Pycraft ('**96**, p. 261) has recently discussed with care the osteology of Archæopteryx. In opposition to the view of Hurst, that the manus retains five digits, two of which were used in climbing trees, Pycraft supports the older view, that digits I, II, III are the only ones represented, and that digit III, as in the Archosauria[1] generally, and in the Dinosauria in particular, had four phalanges, the terminal of which was armed with a claw. In addition to these reptilian characters are the thecodont, or socketed teeth, the flat, or amphiplatyan,

[1] "Archosauria" is a term employed by Cope for reptiles with two cranial arches at the back of the skull, namely, Rhynchocephalia, Crocodilia, and Dinosauria. In the writer's opinion this group should be extended to include the Lacertilia, in which one arch has been lost.

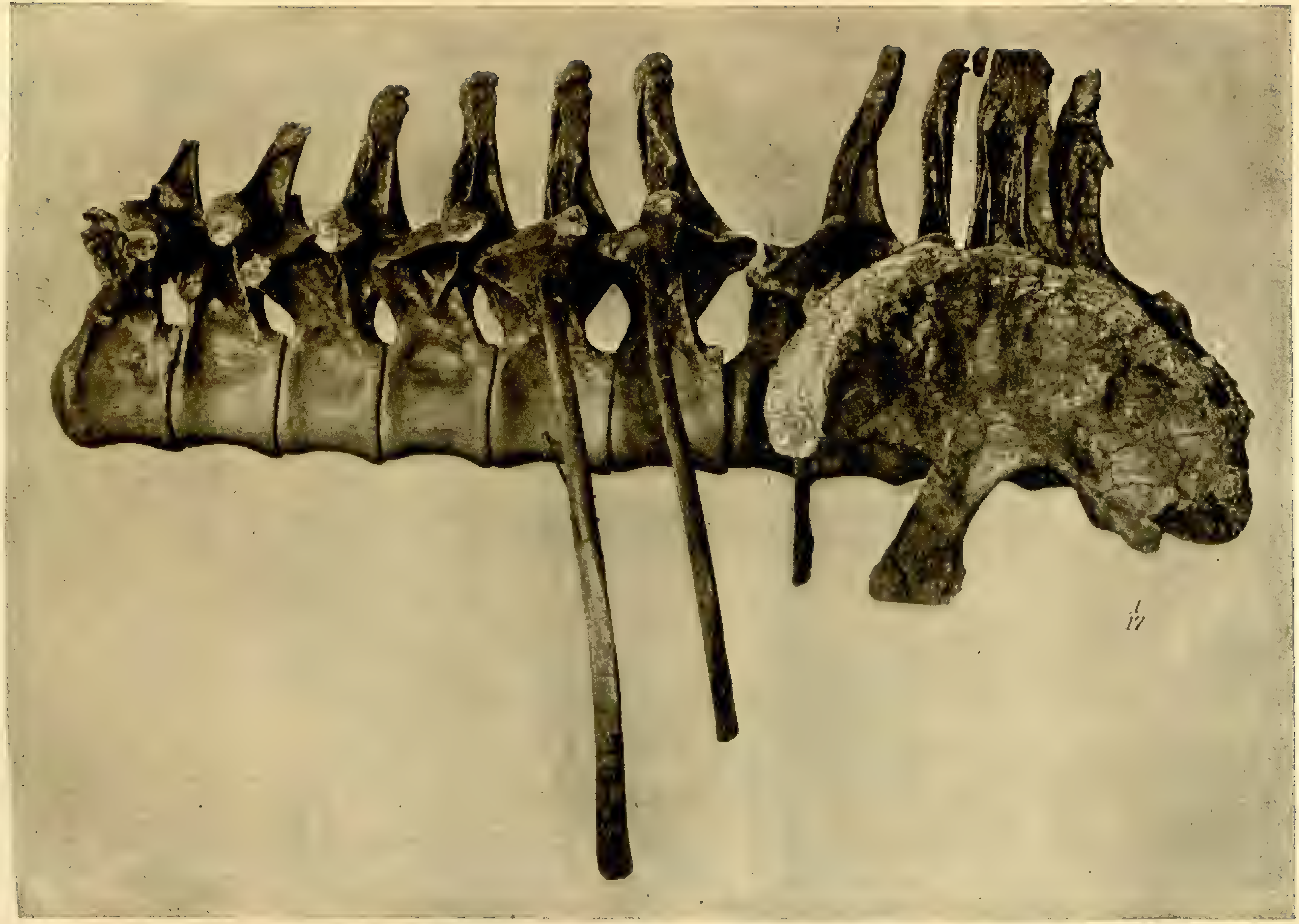


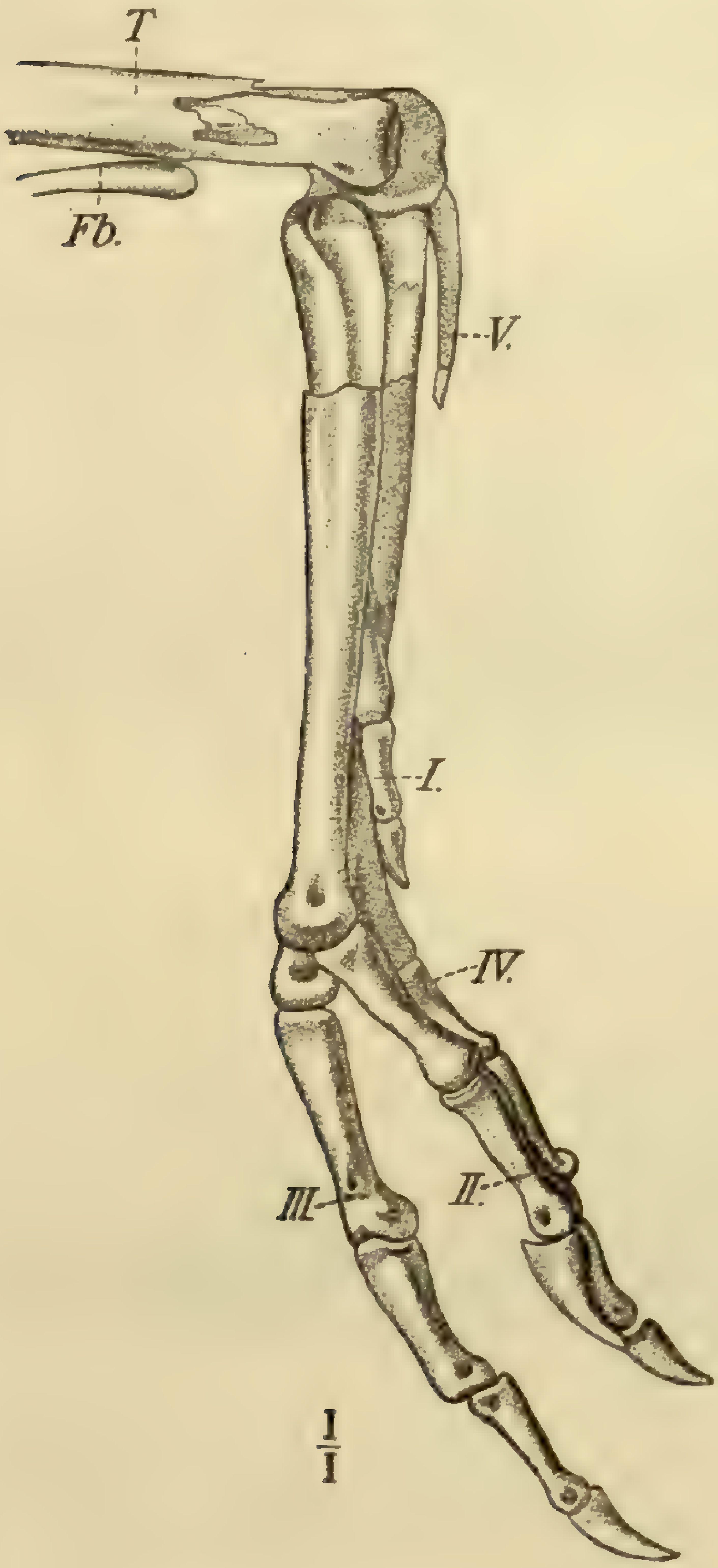
Fig. 8. — Diplodocus. Ninth dorsal vertebra with 9th free rib behind ilium, 10th dorsal, or "pelvic" vertebra, with rib element coalesced with ilium. After Osborn.

FIG. 9. — Apteryx. Ilium overlapping the two posterior ribs 9th and 10th, as in Diplodocus. Decided *ileo-pectineal* process. Uncinate processes as in Rhynchocephalia.

Struthio. On right side, *P.S.*2, 7th dorsal; on left side, *P.S.*1, 8th dorsal, overlapped by ilium; 9th and 10th dorsals absorbed in sacrum.

vertebral centra, the numerous caudal vertebræ. As regards the ribs, Pycraft considers it unsafe to infer that they lack uncinate processes, since these would be readily macerated off; the cervical ribs were slender and movably articulated. Abdominal ribs appear to have been present, as in the Crocodilia and Proganosauria.

In connection with the clawed quadrupedal stage in the history of birds, Opisthocomus, the Hoactzin, proves to be of exceptional interest, "for," as Pycraft remarks, "it is probable



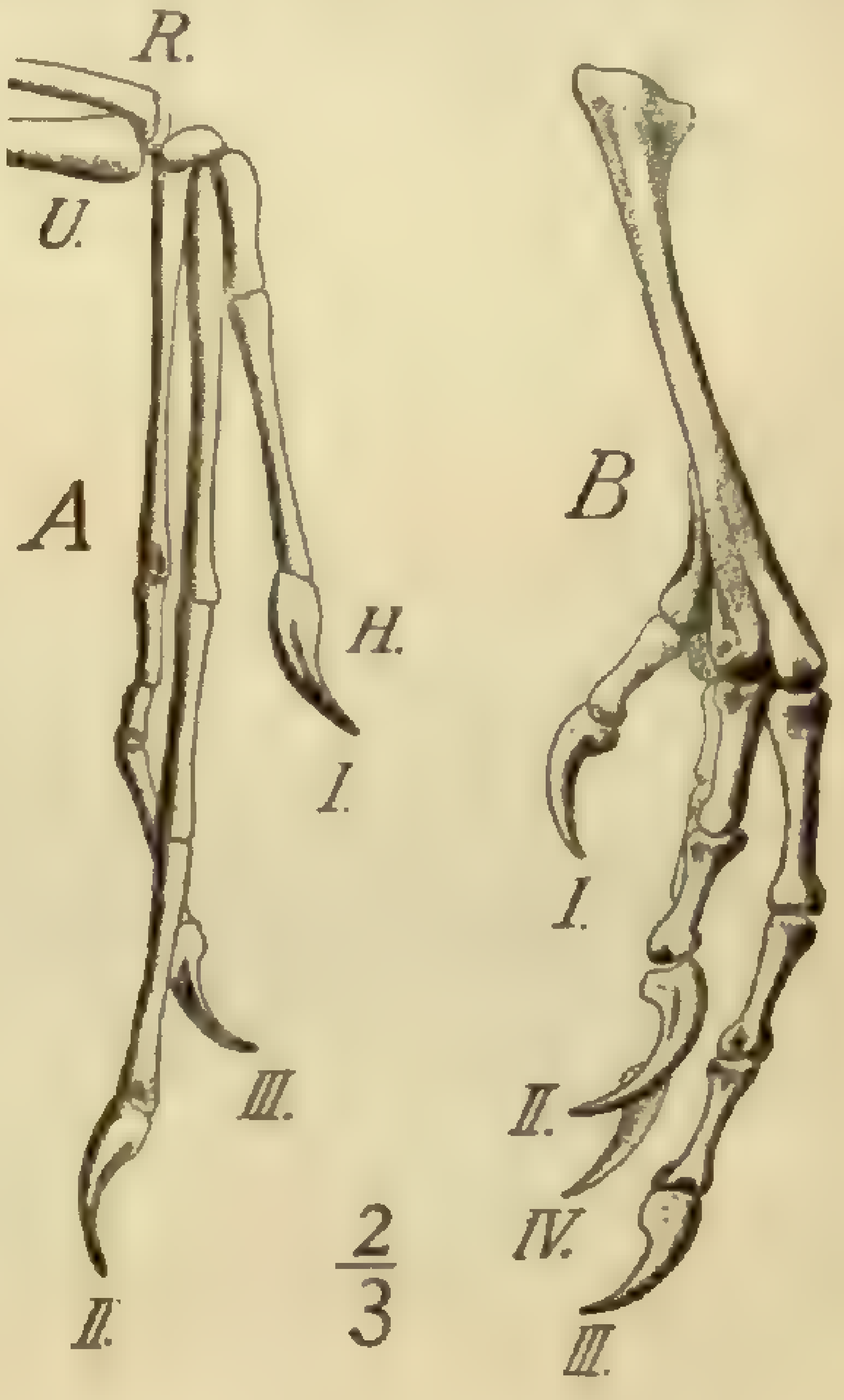


FIG. 10. Compsognathus. Right pes, × 1/1. After Baur.
Archæopteryx. *A*, right manus, × 2/3, from Headley, after Dames; *B*, right pes, × 2/3, after Owen.
T, tibia; *Fb*, fibula; *R*, radius; *U*, ulna; *I–V*, metacarpals and metatarsals.

that the peculiar habits of the nestling may be a survival of an order of things handed down from the very dawn of avian development." The young are reared in trees and at an early age climb out of the nest; the hand is considerably longer than the forearm; the pollex (I) is especially long and provided with a large claw; index II has an equally large claw, which is

produced beyond the skin fold that encloses the bases of the quills. These proportions are peculiar to the nestlings; the adults shorten the hand and lose the claws as soon as they have ceased to be of assistance; but, as Pycraft observes, could we discover a yet more primitive form "it is probable we should find that the claws and long hand were maintained throughout life." Further light upon the quadrupedal habits of primitive birds is given by the very interesting observation of Dean upon the locomotion of young cormorants, which, when frightened, clamber over irregular surfaces with the assistance of the fore limbs. Young gallinules, coots, and grebes are also quadrupedal in habit.

So far, therefore, as the osteology of Archæopteryx and the embryology and habits of recent birds guide us, the theory of a quadrupedal proganosaurian prototype is not excluded.

VI. The Most Primitive Quadrupedal Land Reptiles.

This suggests a consideration of the Proganosauria, the most primitive representatives of the Hatteria phylum, as one of the possible sources of the birds.

The Proganosauria, Baur (= Proterosauria, Seeley), constitute a suborder of Rhynchocephalia and include some of the most ancient reptiles known of the Permian period. They occupy the cleft between Crocodilia, Lacertilia, and Dinosauria.

In his extremely interesting and important papers upon Palæohatteria and Kadaliosaurus Professor Hermann Credner ('**88**, '**89**) has described two proganosaur types from the Permian, near Dresden, one of which approaches most nearly the hypothetical ancestral dinosaur. Palæohatteria, if we may judge by the comparatively unossified extremities of the limb bones, was probably an aquatic type; Kadaliosaurus, on the other hand, was undoubtedly a land type, the limb bones being completely ossified proximally and distally, with spongy interior. The prefix *καδαλίων* refers to the exceptional elongation of the limbs, the proportions of which are well represented in Fig. 11. Professor Credner has pointed out the striking resemblance of the somewhat forward and backward spreading ilium

of this animal to that of a dinosaur. It is further to be noted that, while the forearm is extremely long, the metacarpals are shorter than the metatarsals, which are decidedly long and slender; the skull and shoulder girdle are unfortunately unknown; the number of dorsals is estimated at twenty; there are two sacrals. While the ectepicondylar foramen of the humerus points in the direction of the lizards (in distinction from Palæohatteria, with its entepicondylar foramen), there is no

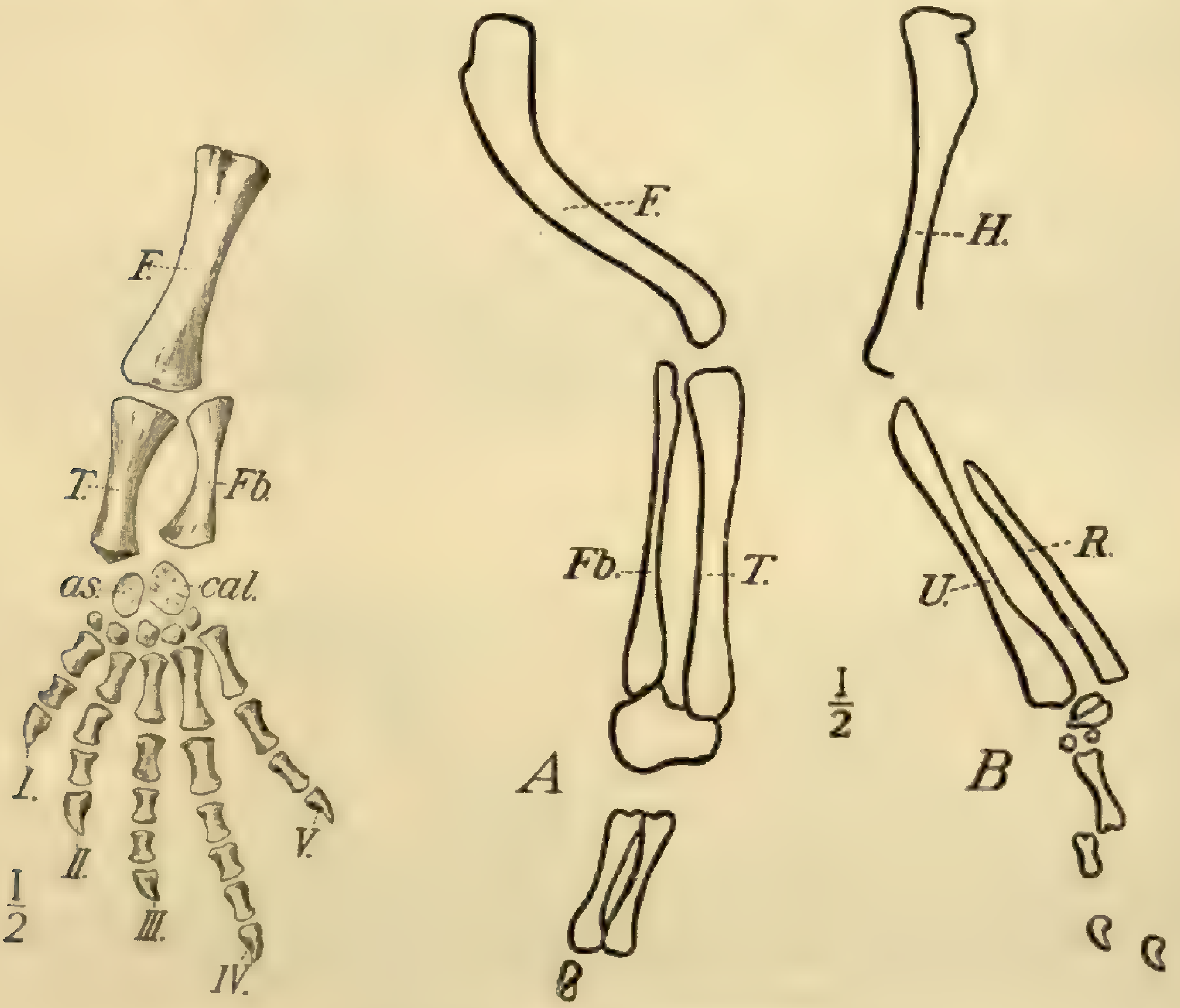


FIG. 11. — Limbs of Proganosauria.

Palæohatteria. A short-limbed, probably amphibious type. Left hind limb. Restored by McGregor, after Credner.

Kadaliosaurus. A long-limbed, probably terrestrial and active type. Metatarsals longer than metacarpals. After Credner.

question that we have here a type which comes very near the dinosaur atavus. The fact that the humerus and femur are of the same length accords with the condition characteristic of the early Cetiosauria, for the Cetiosaurus of Oxford has a humerus and femur of nearly equal length.

The foot structure of Palæohatteria, as restored from Credner's plates by Dr. McGregor (Fig. 11), fulfills all the required ancestral conditions, both for dinosaurian and avian ancestry.

Granting, therefore, for the sake of argument, the hypothetical value of the Proganosauria in the largest sense as

ancestral to all Archosauria, including birds, the crucial question remains, whether birds sprang off independently from a proganosaur stem or from a common dinosaur-avian stem. In the origin of the birds we have to imagine, first, a terrestrial stage, in which bipedal was gradually substituted for quadrupedal progression ; it would appear probable that the bipedal progression was first acquired during a terrestrial stage, because the foot of birds is primarily a walking, and not a climbing, organ ; second, a cursorial bipedal or, more probably, an arboreal stage, in which both fore limb and tail enjoyed a change of function contemporaneous with the acquisition of feathers.

VII. Correlated Development of Tridactylism and Bipedal Progression.

It appears probable that the ancestral dinosaur was a quadrupedal type, with the body well raised off the ground, distinctively a land animal, because the distinctive specialization of this group appears to have been terrestrial, the Cetiosauria or Sauropoda secondarily acquiring an amphibious mode of life. The manner in which the four-footed primitive dinosaurs acquired the bipedal habit and consequent reduction of the fore limbs and elongation of the hind limbs is beautifully illustrated in Chlamydosaurus of Australia and some other living lizards. As observed by Saville-Kent, this animal in all its rapid movements raises the fore limbs, balances the anterior part of the body with the tail, and runs along rapidly upon the hind limbs. This analogy appears to demonstrate that an important function of the tail was to serve as a balancing organ. (We note in parenthesis that this function is developed among birds.) Kent remarks further : "Such is the construction of the hind foot and its component digits that, when thus running, the central digits only, rest upon the ground. As a consequence of this structural peculiarity, the track made by this lizard when passing erect over damp sand or other impressible soil would be tridactyl, like that of a bird, and would also correspond with the tracks that are left in Mesozoic strata by various typical Dinosauria. This tridigitigrade formula of the

gradation of Chlamydosaurus, induced by the great relative shortness of the first and fifth digits, is distinctly indicated in Fig. 1 of the plate previously referred to."

Thus, tridactylism is correlated with rapid bipedal progression, the inner and outer digits suffering reduction. In fact, a glance at the digital formula of Archosauria shows why tridactylism is a likely resultant of rapid digitigrade progression.

Digits . . .	I	II	III	IV	V
Number	1	1	1	1	1
of	2	2	2	2	2
Phalanges		3	3	3	3
in			4	4	
Archosauria				5	

There is considerable ground for regarding a certain degree of bipedalism as a character common to all dinosaurs. Among the carnivorous Megalosauria there can of course be no question, because this condition marks the oldest Triassic types. Osborn, in Diplodocus, has demonstrated the truth of Cope's conjecture that the quadrupedal cetiosaurs occasionally rose upon their hind limbs. Among the Predentata, the Iguanodontia are typically bipedal, and the iguanodont or quadriradiate structure of the pelvis in the quadrupedal Stegosauria and Ceratopsia has led Dollo to advance the somewhat daring hypothesis that these animals also were at one stage more or less bipedal and that their fixed quadrupedal habit is possibly secondary.

FIG. 12. — Chlamydosaurus in rapid motion. From an instantaneous photograph by Saville-Kent.

VIII. Hypothetical Origin of Birds from a Primitive Bipedal Dinosaur.

If bipedalism subsequently proves to be a common dinosaur character, it would naturally strengthen the dinosaur-avian stem hypothesis. The presence of a *free quadrate* in birds, a

difficulty which suggested itself to Marsh, is explainable as a secondary character, like the secondarily free quadrate of certain Lacertilia and Ophidia, due to degeneration of one of the cranial arches.

The passage from a quadrupedal to a bipedal type would also mark the transition from the Proganosauria to the Dinosauria, and all that our present knowledge and evidence justify us in saying is that *in this bipedal transition, with its tendency to form the tibiotarsus, the avian phylum may have been given off from the dinosaurian.*

This form of the Huxleyan hypothesis seems more probable than that the avian phylum should have originated quite independently from a quadrupedal proganosaur, because the numerous parallels and resemblances in dinosaur and bird structure, while quite independently evolved, could thus be traced back to a potentially similar inheritance.

Upon the whole, therefore, the dinosaur-avian stem hypothesis deserves not to be discarded but to be very seriously reconsidered in connection with future research and discoveries among birds and dinosaurs.

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THE GALL OF THE MONTEREY PINE.

W. A. CANNON.

ONE species of pine, the Monterey pine,[1] which is especially abundant in the arboretum of the Leland Stanford Junior University, has recently been so seriously affected by a gall that the beauty of a great number of the trees has been greatly impaired, and their total destruction made probable. The gall is caused, as was first observed by Mr. W. A. Snow,[2] by larvæ of a gallfly belonging to the family Cecedomyiidæ.

The gall consists of a malformation of the leaves and leaf bases. The galled leaves vary in length from .5 to 1.5 cm., and their bases are so badly swollen that the leaves are often pear-shaped. The larvæ live in pockets in the swollen leaf bases. The gall occurs on the youngest leaves, and for that reason leaves containing larvæ are to be looked for at the tips of the branches. Where the same branches have been galled several successive seasons their tips appear as if closely clipped and look like great bottle brushes. The galled leaves do not remain so long on the tree as the normal ones.

If one of the galled leaves be examined the autumn after it has been stung, it will be found to contain in its base four or more larvæ. These are without biting mouth-parts, but they are none the less completely enclosed by plant tissues. It was to learn, primarily, how the larvæ got inside of the leaf base, and also to trace the immediate cause of the hypertrophy, that this study was undertaken. To these were added, in the course of the investigation, other questions of physiological interest.

[1] *Pinus radiata* D. Don., *Trans. Linnæan Soc.*, vol. xvii (1836), p. 441; formerly known as *P. insignis* Loudon, *Arb. Brit.*, vol. iv (1838), pp. 2265, f., 2170–2172.

[2] This study was taken up with Mr. Snow, since deceased, and subsequently carried on by Miss Helen Mills. *The Entomological News*, vol. xi (1900), p. 489.

In dealing with the inner morphology of the galled leaf it was not thought necessary for the purpose of this paper to follow minutely all of the changes in the plant tissues during the development of the gall, but rather to observe the conditions of the tissues in well-marked stages of growth, and contrast them with each other and with the conditions in normal leaves.

I.

In the middle of February the young shoot representing the season's growth of the branch is about 3 cm. long and consists of a central axis covered closely with leaf bundles, or fascicles. There are about seventy leaf bundles, or fascicles, to each young shoot. Each bundle is composed of a short secondary branch bearing three leaves, or "needles," which are closely and completely enwrapped by several protective scales. The whole springs from the axil of the primary leaf (Fig. 1). Early in the season each primary leaf completely covers its leaf bundle, but by the middle of February the leaves begin to grow appreciably and soon stretch up above the tip of the primary leaf. At the tip of each young shoot there will be fascicles hidden by the primary leaves, while at the base of the same shoot these bundles may be twice as long as the primary leaves, and between tip and base an intermediate condition may be found. At the time the gallfly is active the majority of leaf bundles are about 2 mm. in length. The length of the leaf bundle in relation to that of the subtending primary leaf and to that of the ovipositor is of great importance in connection with the successful deposition of the eggs.

To learn in what part the eggs were placed, the young shoots were examined in February, during the activity of the gallfly. The eggs were found deposited in masses on the outside of the young shoot. They were placed, also, in great numbers between the leaf fascicles or between the primary leaves and the fascicles they subtend (Fig. 1, *B*), and it was thought at the time that the fly did not deposit the eggs in any other parts. The young shoots were examined to see if some substance, such as formic acid, were not deposited by the fly at the time the eggs

were laid, which might in this case, as in others, stimulate the plant tissues to abnormal growth and thus bring about the gall. The cells, however, adjacent to the masses of eggs did not show the slightest discoloration or shrinkage of contents, nor did they in any other way that could be discovered indicate that substances were deposited which might stimulate or affect the plant tissues. All of the eggs which were placed on the outside of the young shoots disappeared on the first of March. A closer examination of the leaf bundles showed that, in addition to the great numbers of eggs placed on their surfaces, the

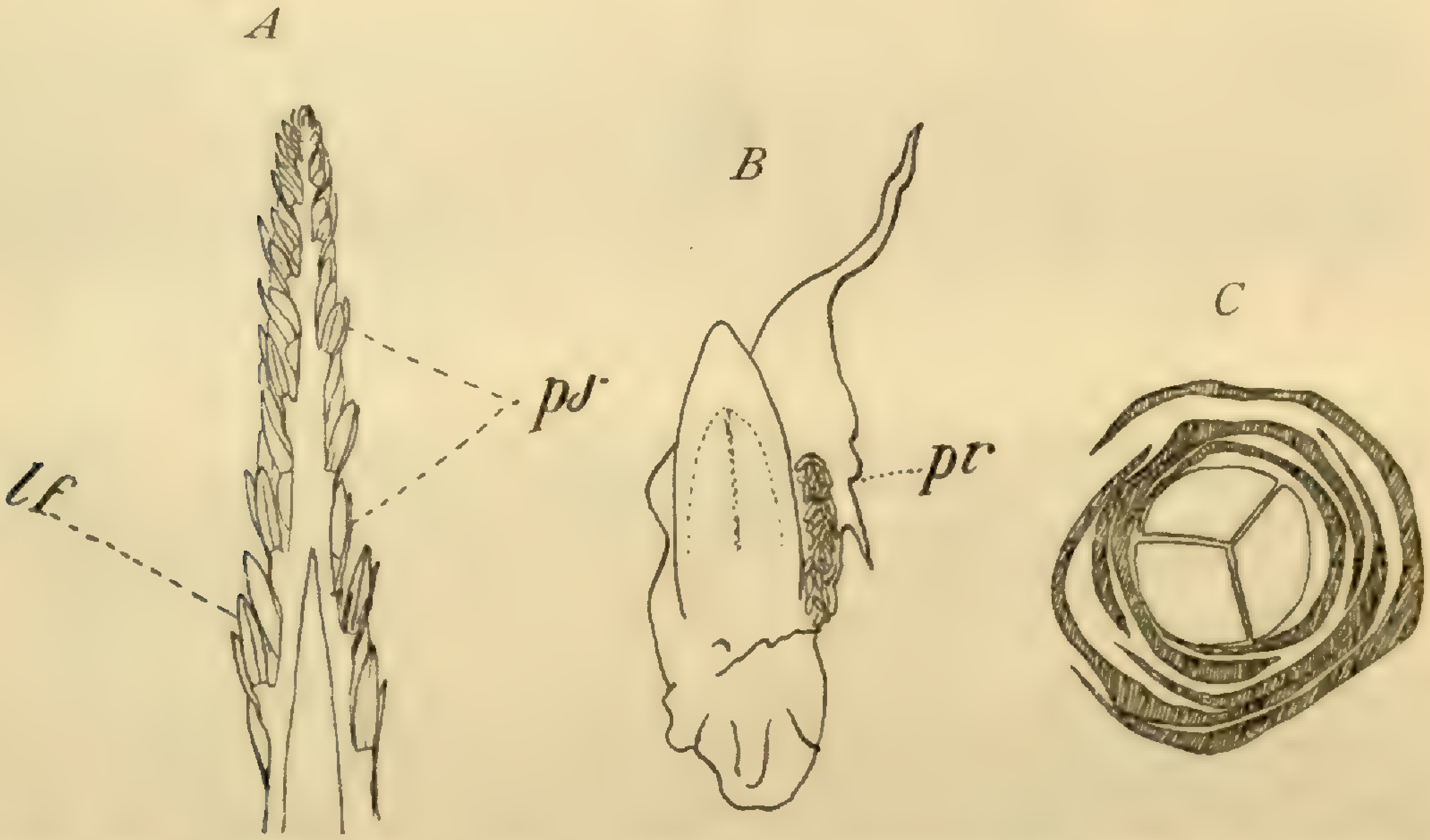

FIG. 1.—*A*, young shoot with leaf fascicles (*lf*) and primary leaves (*pj*). × 2. *B*, dorsal view of a young leaf fascicle with its primary leaf (*pr*) attached, showing a mass of eggs between the two. × *circa* 10. *C*, transverse section of the same with the protecting scales. × *circa* 16.

fly also placed some inside of them. The eggs which were deposited within the leaf fascicles were in much smaller masses than those on the outside. The number of eggs in these masses did not, in any case observed, exceed six. They were found in three positions. Some eggs were between the enwrapping scales, others inside of them but near the tips of the leaves, and still others within and at the bases of the inner scales (Fig. 2, *A*, *B*). These different positions of the eggs might not all be met with in any one bundle, but they were of frequent occurrence. In those cases where the eggs were placed between the scales, and also where they were deposited

within the scales but near the tip of the leaf, they did not give rise to larvæ that matured, because, as will be shown later, the young larvæ were not in contact with living tissue which could give them nourishment. The larvæ take their food only by absorption through the surface of the body. This makes it essential for them to be in contact with living cells, from which the necessary food matters can be abstracted. This condition, namely, that the larvæ must be in physical contact with tissues which will give them food, is fully realized only when the eggs from which they develop are placed at the bases of the inner scales. It is consequently necessary that the distance from the tip of the needles, or in other words the length of the leaves, be approximately the same as the length of the ovipositor of the fly, for only in this way can the eggs be so placed that the larvæ which result from them will live. This exacting condition we find is complied with by most of the leaf bundles of the Monterey pine during the month of February, or during the season of the gallfly's activity.

FIG. 2.—*A*, longitudinal section of a leaf fascicle with eggs placed at the base of the leaves and of the inner protecting scales; one egg is also shown between the scales. × 28½. *B*, longitudinal section showing a mass of eggs at the base of the leaf. × 28½.

II.

All of the young leaves grow rapidly in length during the month of March, and the first week in April most of them are approximately 1 cm. long; thus, they have increased about five times in length in somewhat over four weeks (Fig. 3). Up to the first of April there is no apparent difference between the normal and the galled leaves; from this time on, however, the difference in length and diameter between the affected and

the normal leaf bundles, or fascicles, is increasingly marked. By the first of May the normal leaf bundles are about 3 cm. long, and the galled ones from 1 to 1.5 cm. in length. In addition to the difference in length, the bases of the latter are much swollen, and many of the leaves cease to grow in length, although the diameter of their bases continues to increase until autumn (Fig. 4).

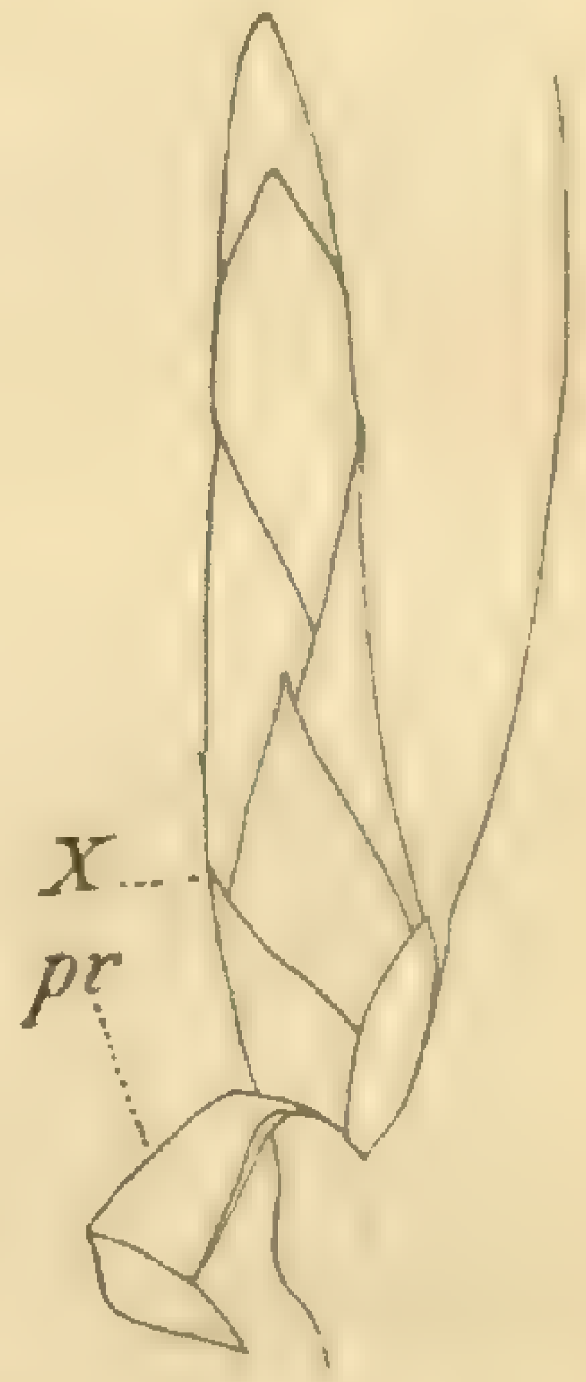

Fig. 3. — Showing the first indication of the hypertrophy at X. March 16. × 4.

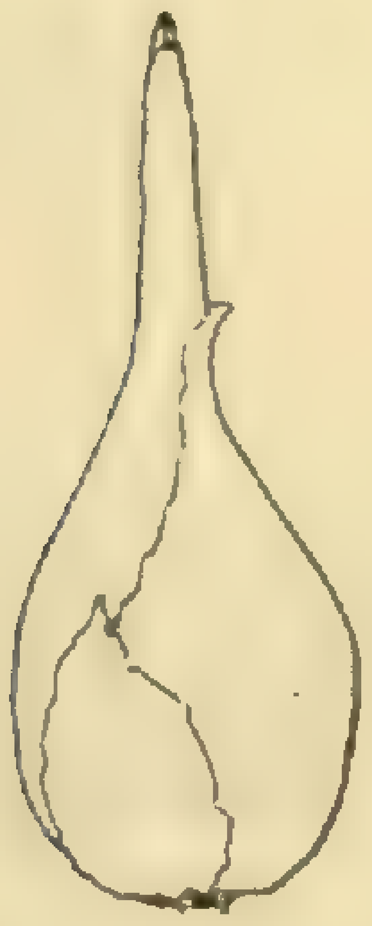

Fig. 4. — A galled fascicle sketched in July. Natural size.

To learn what plant tissues were affected, and in what manner, so that some conclusion might be drawn as to the immediate cause of the hypertrophy, there were selected for more careful study leaf bundles taken in April — the season of great changes and development in the leaf bundle. All of the material was fixed in hot alcoholic corrosive sublimate, a saturated solution in 30 per cent alcohol being used.

If a galled leaf bundle is examined in the middle of April or the first of May, the cavities in which the larvæ lie will be

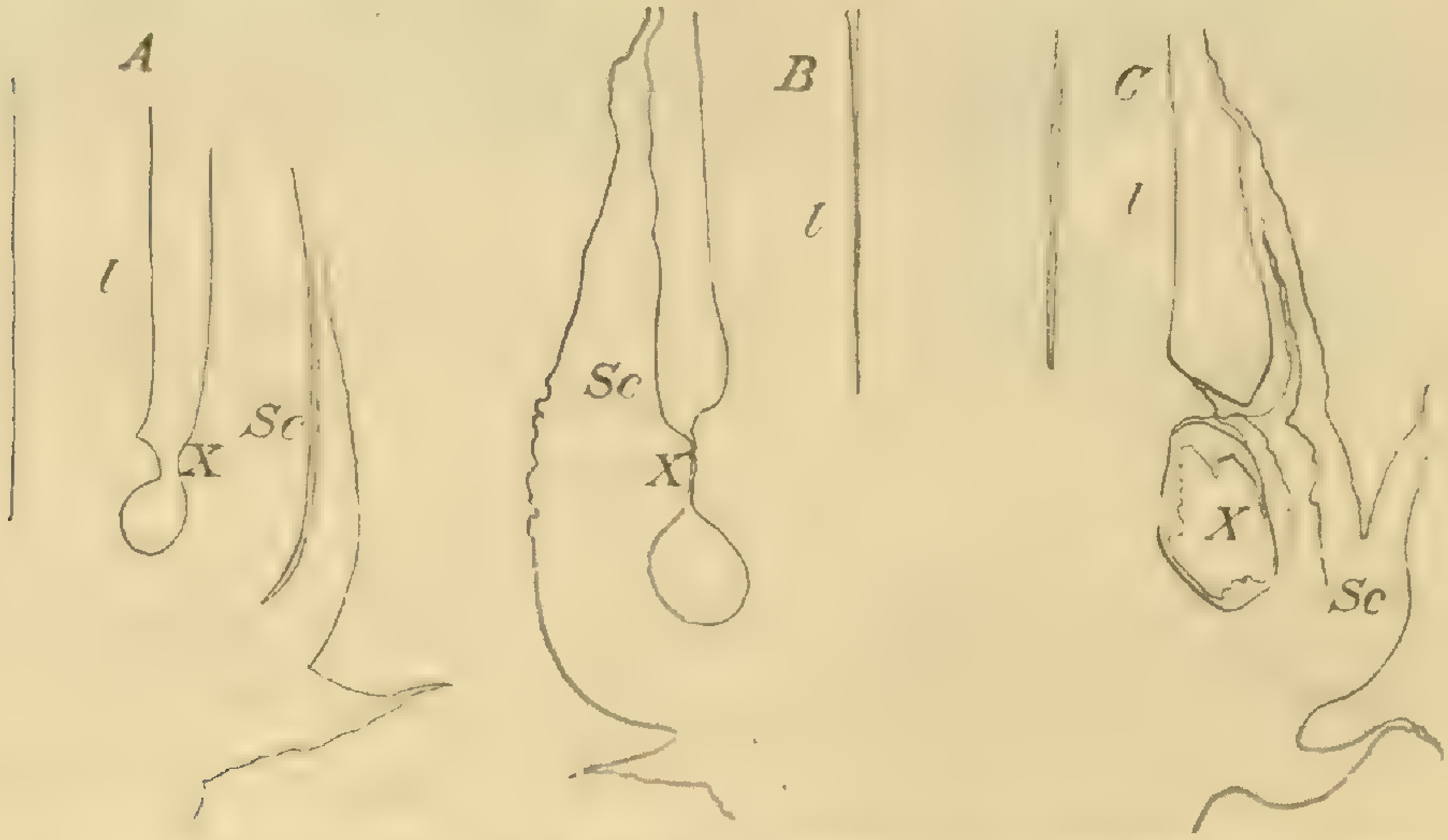

Fig. 5. — Showing the development of the protuberances which enclose the upper part of the larval cavity: *A*, May 1; *B*, July 15; *C*, mature, autumn (*l*, leaf; *Sc*, scale: *X*, development of protuberances and larval cavity). × 28½.

found almost completely developed. The cavity is in the axil of the leaf and is nearly covered above and on the sides by

projections of plant tissue, one from the periphery of the leaf, and another from the inner surface of the inside scale (Fig. 5, *A*). It will be seen by consulting Fig. 6 that the young larvæ are at this time completely surrounded by thin-walled cells, and that the plant tissue which is in contact with the body of the parasite is composed of epidermis, thus showing that the parasite has consumed none of the plant cells or tissues.

The young epidermal cells of the young normal leaf are long, thin-walled, and have little granular contents. The older epidermal cells lose their contents, their outer walls become strongly cutinized, and they serve the plant only as a protective covering.

The epidermal cells of the leaf which are in contact with the larvæ have an appearance quite different from those epidermal cells in the other parts of the leaf. The first difference is noticed in the size and shape of the epidermal cells that line the cavity in which the larvæ lie. They are much longer and deeper than the normal epidermal cells, and they very closely resemble the cells lying beneath them, which are the large mesophyll cells. Furthermore, these epidermal cells are densely filled with granular food matter. Above the larval cavity, where the epidermal cells of the leaf arch over to meet those of the scale, they are shorter and deeper than those leaf epidermal cells touching the larvæ, but they are much larger than the epidermal cells in the older parts of the leaf into which they insensibly merge (Fig. 6). These cells have less contents than those in contact with the larvæ, but more, again, than the normal leaf epidermal cells.

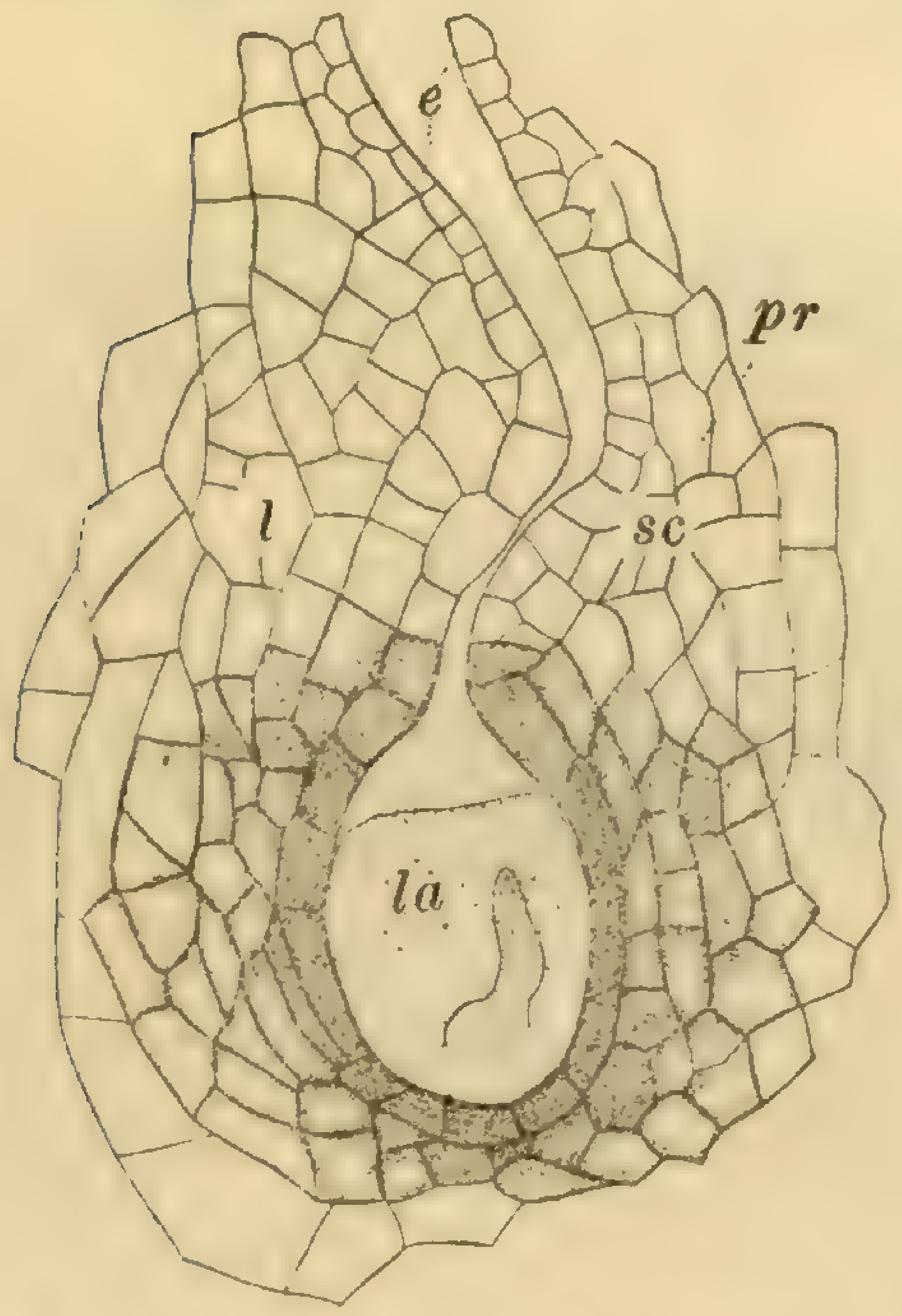

FIG. 6. — Longitudinal section through a cavity containing a young larva. The shaded area indicates the tissues with the densest cell contents (*la*, larva; *sc*, scale; *l*, leaf; *e*, epidermis; *pr*, parenchyma). April 25. × *circa* 56.

The epidermal cells on the inner surface of normal scales are long, shallow, and thin-walled; the epidermis on the outer surface

varies only in the character of the outer cell wall, which, in this case, is thickened and strengthened by transverse ridges. On the inner surface and near the base of the scales the epidermal cells are shorter and resemble those of the leaf at a corresponding distance from the axis. The epidermal cells of the scales have very little contents.

In the galled leaves the scale epidermis lining the cavity in which the larvæ lie consists of long, thin-walled cells, which in size, shape, and density of contents resemble those epidermal cells of the leaf that line the other part of the cavity. The scale epidermal cells are shorter and deeper above the larvæ where the epidermis of the scale and of the leaf meet, and they gradually change into the normal form, somewhat above the neck of the larval cavity (Fig. 6).

It is thus seen that, in consequence of the presence of the parasite, the epidermis of scale and leaf is modified in shape and size, in structure, in contents, and in function.

A cross-section of the base of a galled leaf bundle, made from one of the same age as that represented in the longitudinal section in Fig. 6, shows that the tissue adjacent to the cavities containing larvæ is mainly parenchymatous, *i.e.*, the cells that compose it are relatively large and thin-walled, and are those cells which, in plants, are most sensitive to stimuli.

The tissue of the scale base is composed of large, rounded cells, between which are many intercellular spaces. These cells have but little contents. Near the juncture of scale base and leaf the cells are some of them larger and some smaller, and there are fewer intercellular spaces. In the axil of scale and leaf the cells are normally much smaller than any met with in the scale. Finally, the tissue surrounding the rudimentary conducting tissue, which in galled leaves abuts on the inside of the cavity containing the larvæ, is composed of small cells of the kind just described as occurring in the scale base. The thin-walled mesophyll cells of the leaf normally are differentiated into quite another tissue; as the leaf becomes older these cells become oblong, thick-walled, supporting cells (sclerenchyma) of the mature pine leaf. The cells of the tissues described have but little contents.

The parenchymatous tissue of the scale and leaf which is in contact with the epidermis of the cavity containing larvæ, for two or three cells from the cavity, follows the shape, size, and appearance of the epidermal cells (Fig. 6). Beyond these layers of parenchyma the cells become larger than in normal corresponding tissue, and gradually merge into the tissues of the scale on the one hand, and of the leaf on the other. These cells for six or eight layers around the cavity are filled with granular matter that increases in density toward the cavity.

The parenchymatous tissues which surround the parasite are affected in a negative manner as well. They are prevented from being differentiated and from developing as do their fellows under normal conditions. The scales in the normal leaf bundle turn brown early and die. They form the cup which surrounds the bases of the three leaves, or "needles," and which persists during the period of the normal leaf's activity. In the scales of the galled bundle the parenchymatous tissues remain active until early autumn, or during the activity of the parasite. Those cells of the leaf inside the region of the cavities containing larvæ, as has been stated, become in normal leaves thick-walled supporting tissue. In galled leaves they become, when fully developed, as large as the underlying parenchyma, and their walls in thickness reach a condition intermediate between the thick-walled supporting tissue, or sclerenchyma, and the parenchyma.

It is to the change in form and size of the cells which surround the cavity containing larvæ that the hypertrophy is due.

In July the condition of the galled leaf bundles of the Monterey pine differs only in degree from that just described as their condition in April. The parenchymatous cells are somewhat larger, the epidermis of the cavity containing larvæ, and all of the cells in the adjacent tissues of the scale and leaf, are active in providing food for the growing larvæ.

III.

We come now to the question, What is the immediate cause of the hypertrophy? And to this only an imperfect, and perhaps

unsatisfactory, answer can be given. And this must be based on the all too slight evidence which lies before us.

There is no indication that the hypertrophy is either caused or affected by any substance deposited with the eggs.

Extensive experimentation would be necessary to prove what the effect would be of a foreign body, living or lifeless, in contact with such plant tissues; or, again, how much the waste matter given off from a living body would affect the tissues. There is some evidence, although negative, touching the former in the cases cited above, where the eggs of the gallfly were placed either between the scales or between the inside scale and near the tip of the leaf. In neither of these cases did the larvæ mature, and the reason for this must be that the cells which touched the young larvæ were not such as could easily give up their contents to nourish the parasite. In either case, however, they hatched into larvæ, and we may believe that, although no food may have passed from the cells of the host to the parasite, yet the plant tissues may have been mechanically irritated by the mere presence of a living foreign body. That the leaf epidermis was thickened would appear to make no difference if the plant tissues in question were stimulated to abnormal growth, mostly by this mechanical irritation, because cases are not wanting among plants[1] in which epidermal cells, although strongly cutinized, have been rejuvenated and have been caused to perform functions other than normal, or at least usual, and this, too, mainly from external mechanical stimulation. It is highly probable that the mere presence of the parasite does, to some extent, in the case of this gall, as in others, stimulate the living plant tissues.

Briefly it appears that the immediate and principal cause of the hypertrophy is the response on the part of certain plant tissues to the parasite's demand for food. This is indicated mainly by the gradual enlargement of the cells surrounding the parasite, in a manner which corresponds to its growth, and also by the unusual amount of food material which these cells contain.

[1] Peirce, G. J. On the Structure of the Haustoria of Some Phanerogamic Parasites, *Annals of Botany*, vol. vii (1893), No. 27, p. 295.

IV.

I have been asked, why does not this gall attack other species of pine? and it may be said that one other species, of half a dozen that were examined which are growing in the Stanford University arboretum (*Pinus attenuata*), has a few galled leaf bundles. The young shoot of this pine is, early in the growing season, similar in structure and size to that of the Monterey pine, but the leaves of *P. attenuata* do not remain the right length for being visited by the gallfly long enough to be seriously injured by it. The other species of pine do not develop their shoots at the right time, or the shoots are covered with resin, or they are otherwise unfitted either by size or by structure to be galled. The opinion may be ventured that the conditions for the proper laying of the eggs and those governing the life of the larvæ are so delicate and exacting that other species of our pines are not likely to suffer from the parasite.

The materials for this paper were collected in the spring and summer of 1898, from galled Monterey pines which were growing in the university arboretum.

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NOTE ON DISTOMUM ARCANUM (N. SP.) IN AMERICAN FROGS.

W. S. NICKERSON.

In frogs used for laboratory dissection I have observed, in many cases, cysts forming considerable swellings just at the pylorus. These, when opened, are found to contain small distomes, together with a mass of friable material, which under the microscope is seen to consist in part of eggs and in part of a finely granular stainable substance whose source I have not determined. The worms, though closely resembling several species which inhabit the intestines of European frogs, seem nevertheless to be distinct from them morphologically, and have, I believe, not been mentioned heretofore. I shall describe them under the name *Distomum arcanum*, the specific name referring to their being concealed from view in the cyst. So far as observed, the cysts occur always, when present, just at the pylorus, where they form conspicuous rounded swellings, about three millimeters in diameter. In extreme cases of infection as many as four or five of these may be present in the same frog. Two worms are usually present in a cyst. The wall of the cyst is composed of fibrous tissue and smooth muscle, which completely surround and enclose the contents. Several series of sections of cysts and contents have failed to show any indication of a connection between the cavity of the cyst and the lumen of the intestine. The accumulation of so large a mass of eggs and other material within the cyst tends further to disprove the existence of an opening from the cyst. The sexually mature worms have been completely imprisoned by their host.

The preserved specimens are small, stout, ovoidal, or spheroidal worms, the largest measuring $2\frac{1}{2} \times 1\frac{3}{4}$ mm., and the average size being about $1\frac{1}{2} \times 1\frac{1}{4}$ mm. The rather small suckers are of nearly equal size, the oral being slightly larger than the ventral. The latter, which is rather feebly developed,

is about two-thirds the length of the animal from the anterior end. The surface of the body is thickly set with minute scales or spines, which diminish in size toward the posterior extremity. The sexual orifice is near the left side, ventral, rather nearer to the oral than to the ventral sucker. The excretory pore is dorsal, nearly terminal, median, surrounded by a small cluster of gland cells.

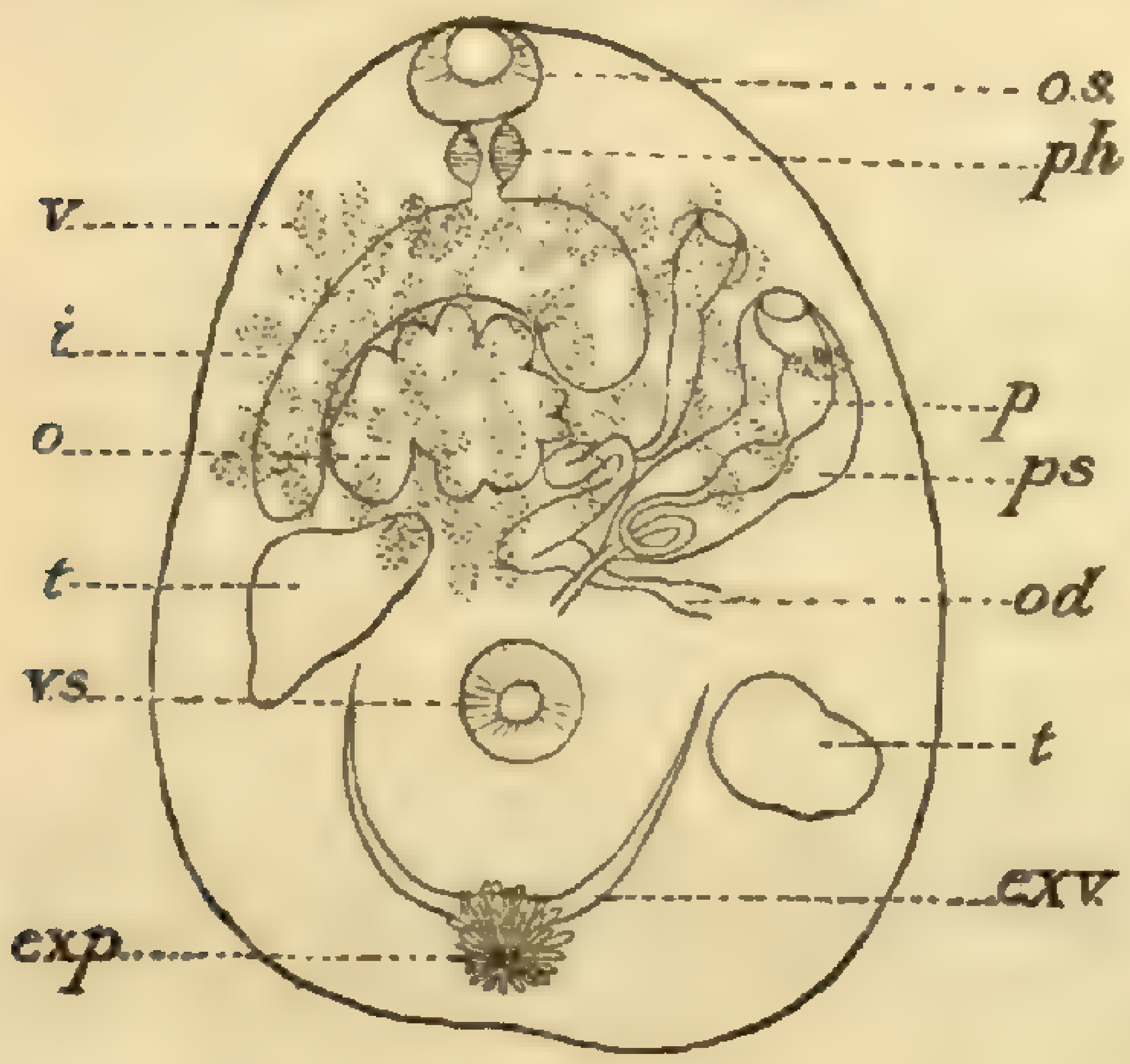

FIG. 1. — Outline drawing of *D. arcanum*, showing positions of chief organs as seen from ventral side. Uterus (except terminal portion) not represented. Camera outline × 38. *exp*, excretory pore; *exv*, excretory vesicle; *i*, intestine; *o*, ovary; *od*, oviduct (terminal portion); *o.s.*, oral sucker; *p*, penis; *ph*, pharynx; *ps*, penis sac; *t*, testis; *v*, vitellary glands; *vs*, ventral sucker.

The pharynx is small and placed immediately behind the oral sucker, and is followed at once by the bifurcation of the intestine. The limbs of the intestine are short and sac-like, extending backward, not farther than the middle of the body. The walls are thin and feebly developed.

The ovary is irregular in form or lobulated, and is situated just behind the forking of the intestine, a little to the right of the median line. Vitellary glands lying nearer the ventral surface are irregularly distributed through a zone extending from about opposite the pharynx back nearly to the ventral sucker. They appear as small cell-clusters or masses having a loosely dendritic arrangement.

The region of the union of the oviduct with the ducts from the vitellary glands and of the giving off of Laurer's canal is in the central portion of the body, just back of the ovary and nearer the dorsal surface, but the exact arrangement of these tubules I have not made out. The shell gland is readily seen in sections but not usually evident in entire preparations. Laurer's canal opens on the dorsal surface posterior to the ovary, nearly over the ventral sucker. The oviduct or uterus fills the greater portion of the space remaining between and around the other internal organs, but its folds appear to lack any definiteness of arrangement.

There are two testes, somewhat elongated or of slightly irregular outlines, situated one upon either side of the body, about in line transversely with the ventral sucker. The penis sac is a prominent organ at the left of the ovary and having a length of about one-fourth the length of the worm. It has thick muscular walls within which the retracted penis lies coiled.

The vagina, or terminal portion of the oviduct, opens immediately beside the opening from the penis sac and in front of it. The two openings appear in many specimens as separate apertures upon the surface of the body; in others they open into a common groove or depression of the body wall or genital atrium.

The eggs are elliptical or very slightly ovoidal in outline, measuring about $23 \times 13\ \mu$. The line of separation of the lid is usually not evident.

The excretory vesicle forks just in front of the excretory pore, forming two tubules which diverge as they extend forward near the testes, beyond which I have not traced them.

It will be seen from the foregoing description that *D. arcanum* is closely related to several species which it resembles in its small size, compact form, spiny covering, rudimentary intestine, and laterally placed sexual aperture, as well as in being parasitic in the intestine of the frog. *D. medians* is the form which it resembles most closely, the two species being essentially alike in many respects. *D. medians* has, however, a regular rounded ovary, situated on the right side, while, as already stated, the ovary in *D. arcanum* is lobulated and nearly median in position. The latter species appears also to be a little smaller and less elongated. The vitellaria, also, are distributed over a zone whose breadth is about one-half the length of the worm, while *D. medians* has the vitellaria restricted to the anterior quarter of the animal. Measurements of the eggs of the two species show that they also differ in size. There is further to be taken into account the fact that *D. medians* lives free in the intestine in (European) frogs, while *D. arcanum* is found completely enclosed within cysts at the pylorus of

SMALL DISTOMES WITH LATERALLY PLACED GONOPHORE (LEFT) AND SPINY COVERING.[1]

	Ovary.	Testes.	Intestine.	Suckers.	Size, mm.	Ova, μ.	Occurrence.
D. clavigerum Rud.	rounded, on right side, near ventral sucker	in hinder part of body	forks long	oral larger, 3 : 2 (2 : 1)	– 3.3 long	33 × 16	intestine of frogs, etc. (European)
D. medians Olsson	round or oval, on right side, opposite fork of intestine	laterally placed in line with ventral sucker	forks reach middle of body	oral larger, 14 : 11	2 × 1	30 × 16	intestine of frogs and toads from pylorus to midway of intestine (European)
D. confusum Looss	rounded, median, in front of ventral sucker	near anterior end, in line with pharynx, one on each side	forks short	oral little larger, 16 : 15	1.36 × 1	34 × 13	intestine of frog, etc., at pylorus, not back of opening of gall duct (European)
D. arcanum n. sp.	lobulated, nearly median, just back of fork of intestine	laterally placed in line with ventral sucker	forks short, not reaching beyond middle of body	oral little larger	1.5 × 1.25 (largest 2 × 1½)	23 × 13	in cysts at pylorus of frogs (American)

[1] The descriptions of the three European species are as given by Looss (1894), *Die Distomen unserer Fische und Frösche.*

(American) frogs. In view of these differences there can, I think, be no question that the two forms are distinct species.

From *D. clavigerum* it differs in being smaller and less elongated and in having short limbs to the intestine, while in that form the limbs of the intestine reach nearly to the posterior end of the body.

It is readily distinguished from *D. confusum* by the fact that the latter form has the testes far forward, alongside of the pharynx. The resemblances and differences of these four forms may be best shown perhaps by the tabular statement on the opposite page of their chief characteristics.

I have collected about fifty specimens of *D. arcanum*, all from frogs dissected in Massachusetts. I have not found them in western frogs. No record was kept of the species of frogs from which specimens were taken, and I have, therefore, no means of judging whether it occurs in all the different species or only in particular ones. The specimens collected were taken from frogs used for laboratory dissection, the greater number being the larger common species, except the bullfrog (*R. catesbiana*).

I had hoped to supplement these observations, made mostly several years ago and in large part upon preserved specimens, by the study of other living worms; but, as such specimens are not to be obtained in Minnesota, it seems best to publish such notes as I have without further waiting.

University of Minnesota,
July 17, 1900.

INSTINCT OR REASON?

G. W. and E. G. Peckham.

In our work on the instincts of solitary wasps[1] we included among the true instincts the way in which the wasp acts after bringing her prey to the nest, and gave as an example the habit of *Sphex ichneumonea* in placing her grasshopper at the entrance to the tunnel and then running in and out again before dragging it down. We also referred to the experiment of Fabre on a Sphex, in which he took advantage of the moment that the wasp was out of sight below to move her prey to a little distance, with the result that when the wasp came up, she brought her cricket to the same spot and left it as before, while she visited the interior of the nest. Since he repeated this experiment about forty times, and always with the same result, it seemed fair to draw the conclusion that nothing less than the performance of a certain series of acts in a certain order would satisfy her impulse. She must place her prey just so close to the doorway; she must then descend and examine the nest, and after that must at once drag it down, any disturbance of this routine causing her to refuse to proceed. We recently found a *Sphex ichneumonea* at work storing her nest, and thought it would be interesting to pursue Fabre's method and find out whether she were equally persistent in following her regular routine. We allowed her to carry in one grasshopper to establish her normal method of procedure, and found that, bringing it on the wing, she dropped it about six inches away, ran into the nest, out again, and over to the grasshopper, which she straddled and carried by the head to the entrance. She then ran down head first, turned around, came up, and, seizing it by the head, pulled it within. On the following day, when she had brought the grasshopper to the entrance of the nest, and while she was below, we moved it back five or six

[1] *Instincts and Habits of the Solitary Wasps*, p. 232, 1898.

inches. When she came out she carried it to the same spot and went down as before. We removed it again with the same result, and the performance was repeated a third and a fourth time; but the fifth time that she found her prey where we had placed it, she seized it by the head and, going backward, dragged it down into the nest without pausing. On the next day the experiment was repeated. After we had moved the grasshopper away four times, she straddled it and carried it down into the nest, going head foremost. On the fourth and last day of our experiment she replaced the grasshopper at the door of the nest and ran inside seven times, but then seized it and dragged it, going backward into the nest.

How shall this change in a long-established custom be explained except by saying that her reason led her to adapt herself to circumstances? She was enough of a conservative to prefer the old way, but was not such a slave to custom as to be unable to vary it.

EDITORIAL COMMENT.

Doubtful Economy. — That much of the work done by the United States through the Department of Agriculture and by the various State Commissions and Experiment Stations is of high practical importance has long been recognized both here and abroad.

Scientific men may, however, well hesitate before endorsing many of the recommendations advocated. The application of kerosene as a preventive against mosquitoes should be used only when other methods are not applicable. The destruction of herons, kingfishers, loons, grebes, and other birds, advised by the Superintendent of Hatcheries in the *Third Annual Report of the Commissioners of Fisheries, Game, and Forests of the State of New York*, shows the extreme to which practical science tends. These birds have a scientific value and interest equal at least to the gastronomic value of the trout they destroy, and the State of New York can better afford to establish a hatchery for the benefit of the bearers of fur and feathers than to countenance or allow their slaughter.

Frazer's Life of Cope. — The August issue of the *American Geologist* is devoted chiefly to a memoir by Dr. Persifor Frazer, entitled "The Life and Letters of Edward Drinker Cope." The life is told mainly by the letters ; Dr. Frazer's threads connecting them are slight, and though appreciative are sadly lacking in the happy touches needed for the subject. The illustrations include an interesting portrait of Cope at ten years of age and several reproductions from pen-and-ink drawings made when their author was still a lad. The care and faithfulness shown in these drawings are remarkable, qualities not fully recognized by Dr. Frazer's comparative praise. Gill's admirable address delivered at the Detroit (1897) meeting of the American Association for the Advancement of Science is not mentioned in the list of biographies.

The Biological Bulletin. — From the programme of the Biological Departments of the University of Chicago, 1900–1901 (p. 4), it would appear that the publications of the University included both

the *Bulletin* and the *Journal of Morphology*, and also that contributions were limited to zoölogy and general biology. It may be well to note that the *Biological Bulletin* is still published under the auspices of the Marine Biological Laboratory, and is open to botanical as well as zoölogical papers.

REVIEWS OF RECENT LITERATURE.

PSYCHOLOGY.

Individual Psychophysiology of the Crayfish. — In what sense, if at all, may the term "individuality" be applied to the crayfish? is the question which Dr. Dearborn[1] has attempted to answer experimentally.

Starting with the definition, "a living organism is an individual in proportion to the relative constancy and strength of its own proper tendencies considered as manifestations of an inherent will," the writer, by studying the individual reactions of about twenty representatives of *Cambarus affinis*, arrives at the conclusion that there is no evidence of psychic individuality.

The experiments upon which this conclusion rests are: 1. The determination of traction strength, or the pulling power of the animal. The traction power per gram of body weight varies from 1.7 to 3.5. Three tests were made for each individual on different days, and great variation is noticeable. 2. The pinching power of the chelæ. 3. Returning habits; the crayfish being placed on its back on a *glass plate* and *allowed to right itself if possible.* In this, too, there is remarkable variability. It is an interesting and suggestive experiment, by the future use of which much should be learned concerning the mechanism of the crayfish. 4. Training in the returning habit. Training was given in a particular method of returning, but with negative results. 5. Reactions to galvanism. 6. Galvanotropism. The animals invariably go to the cathode, although at widely differing rates. 7. Hypnosis. Crayfish are easily hypnotized by holding them firmly in a stable position for a short time. Dr. Dearborn emphasizes the fact that the time necessary for hypnosis varies greatly in different animals and in the same animal from time to time, as does also the duration of the hypnotic influence. He differs from Verworn in holding the process of hypnosis in the crayfish to be the same as human hypnosis. 8. Reaction time. The reaction of the forceps of the chelæ to tapping on some part of the shell (the

[1] Dearborn, G. V. N. Notes on the Individual Psychophysiology of the Crayfish, *Amer. Journ. of Physiol.*, vol. iii, No. 9 (1900), pp. 404–433.

place of stimulation is indifferent, the writer states) was determined for ten animals, and found to vary from .20 second to .65.

A comparative study of the results of these experiments "fails to discover anything . . . so far comparable to individual temperaments" as "sensitive and weak" or "dull and strong." "Absence of correlations and inconstancy are the two significant features of the results."

The value of this work, it would seem, lies chiefly in its suggestiveness. Almost every page of the report points out some line of work which might claim months of careful study. Much of the evidence furnished by the experiments seems to us inconclusive because of an insufficient number of observations. Dr. Dearborn has, by the use of the "extensive" method, exposed himself to the criticism "fragmentary and superficial."

R. M. Y.

The Problem of Innate Ideas.— The third of Dr. Ad. Wagner's *Studien und Skizzen aus Naturwissenschaft und Philosophie*[1] is a philosophic discussion of "innate ideas." Of the two earlier papers of this series the first dealt with scientific thought and popular science, the second with the problem of free will.

Dr. Wagner calls attention to the far too common avoidance of fundamental problems by natural scientists . . . "der Naturgelehrte meistens sagen: Ach was! Ich bin Naturforscher. Lasst mich mit Eueren philosophischen Problemen in Ruhe! Die gehen mich nichts an."

In this short essay the nature of knowledge is very clearly and concisely treated. In many respects Wagner's standpoint is Kantian. He considers space, time, and causation "forms" of thought. The latter part of the paper is devoted to the relations of the brain as the organ of mind to the "*a priori*" (commonly so-called) of knowledge.

R. M. Y.

Empirical Teleology.[2]— It seems unfortunate that Cossmann should have chosen a title so unattractive to the majority of biologists as "Elements of Empirical Teleology," for there is much in his book worthy of their attention.

[1] *Ueber das Problem der angeborenen* (*apriorischen*) *Vorstellungen.* Berlin, Gebrüder Borntraeger, 1900. 77 pp.

[2] Cossmann, Paul Nikolaus. *Elemente der empirischen Teleologie.* Stuttgart, A. Zimmer, 1899. 132 pp.

The work consists of two parts, of which the first treats of the teleological laws of nature, and the second of the methods for the investigation of these laws.

Necessary connections or natural laws the author finds to be the objects of science. Empirical science, and especially the scientific concept of cause, is discussed to some extent, but by far the greater part of the book is devoted to what might be termed the philosophy of biology.

Causality, having been defined in terms of general empirical science, and also of special biological science, the biological concepts of living, organic, etc., are analyzed in an interesting fashion.

Under methods of investigation the possibility of methodical work in the teleological sphere is discussed in connection with the standard methods: induction and deduction.

R. M. Y.

ZOÖLOGY.

The Effect of the Staleness of the Sex-Cells upon Development and upon the formation of hybrids has been reinvestigated by Dr. H. M. Vernon.[1] He finds in the case of the echinoderms that the number of normal blastulæ formed from sex-cells kept for some time in sea water diminishes about one per cent per hour up to the twenty-seventh hour, after which time abnormalities rapidly increase in number. Within this period the same decrease was noted whether either or both of the sexual products were stale, but after the twenty-seventh hour the decrease in normal embryos was most rapid when both of the sex-cells were in this condition. The larvæ obtained from stale sex-cells were of the normal size, though when the sperm alone was stale they were often larger, and when the ovum was stale they were smaller, than those derived from fresh products. Contrary to the conclusion of the Hertwigs, staleness of the ova in hybrids of Sphærechinus ♀ × Strongylocentrotus ♂ did not increase the number of hybrid plutei, though in the reciprocal cross a larger percentage of blastulæ was produced. The hybrid larvæ obtained on crossing Sphærechinus ova with Strongylocentrotus spermatozoa vary

[1] Vernon, H. M. The Effect of Staleness of the Sexual Cells on the Development of Echinoids, *Proc. Roy. Soc.*, vol. lxv (1899), pp. 350–360.

Vernon, H. M. Cross Fertilization among Echinoids, *Arch. f. Entwickelungsmechanik der Organismen*, Bd. ix (1900), pp. 464–478.

in type at different seasons of the year. In the summer, when the sexual products of the latter are at a minimum of maturity, the hybrids show a greater resemblance to pure Sphærechinus plutei than do those obtained in the spring. C. A. K.

Protozoan Studies. — The continuation of Dr. Prowazek's[1] work upon the Protozoa contains his observations on many species and discussions of many protozoan problems for whose solution the fragmentary evidence offered, though important in its bearings, is often insufficient. The reproduction of the Rhizopoda is illustrated by stages in the copulation of Euglypha and Trinema, and by sporulation in the autumn months in the same genera and also in Nebela, though no relation between the two processes was detected. These genera are frequently parasitized by *Achromatium oxaliferum*, and in this condition superficially resemble stages in sporulation. Autotomy was observed in Amœba and in Nebela, the rejected portion of the body usually containing the detritus from food vacuoles. From many observations on different species the author concludes that the formation of pseudopodia is always initiated by the ectoplasm. The structure and movements of flagella and of cilia are discussed and the inclusions in protoplasm are described and classified. Six types of non-living inclusions are recognized: (*a*) the Microgranula, composed of minute particles, the products of metabolism, found principally near the vacuoles and the ectoplasm; (*b*) the Hyalogranula, derived from the first and composed of transparent, bluish-green, somewhat refractive, elongate or flattened granules which are abundant near the vacuoles in the endoplasm and are also frequently found on cysts and in gametes; (*c*) the Lamprogranula, consisting of yellowish or greenish, spherical or oval, highly refractive bodies apparently enclosed in vacuoles and usually exhibiting Brownian movements; (*d*) excretory inclusions of spherical form, often with concentric structure and central cavity; (*e*) excretory crystals of various types; (*f*) the Leucogranula, composed of colorless, slightly refractive granules in the ectoplasm of Stentor and some other ciliates.

A sessile heliozoan of unique form and habitus, *Myxodiscus crystalligera*, is described from a marine aquarium. Sessile life has induced a polar differentiation, the pseudopodia being confined to the free surface. Its food consists of ciliates. *Phacodinium muscorum*, a new ciliate, is described from damp woodland moss. C. A. K.

[1] Prowazek, S. Protozoenstudien, II, *Arb. zool. Inst. Wien*, Bd. xii (1900), 58 pp., 2 pls.

The Aleurodidæ. — The insects so named constitute a family of Homoptera, allied to the Coccidæ, but having four wings in the adults of both sexes. Two genera are recognized, Aleurodes and Aleurodicus. We have before us the first attempt at a revision of the American members of this family, written by Professor A. L. Quaintance of the Georgia Experiment Station.[1] All the species of North and South America, so far as yet recognized in the literature, are enumerated, and many new species are described. Although the group is quite numerous in species, some of which are decidedly of economic importance, it has been strangely ignored in the past by American entomologists. Only the following species were described previous to 1880: *Aleurodes phalænoides* Blanchard, 1840 (not now recognized), *A. cocois* Curtis, 1846 (now referred to Aleurodicus), *A. abutilonea* Haldeman, 1850, *A. corni* Haldeman, 1850, *A. asarumis* Shimer, 1867 (now referred to Aleurodicus). At the present time Professor Quaintance is able to list forty-two species of Aleurodes and ten of Aleurodicus. All the species of the latter genus are tropical or subtropical, except *A. asarumis* from Mt. Carroll, Ill. This last is not now known to exist in collections, and is placed in Aleurodicus because Shimer says the central vein branches. It seems just possible to the writer that it is an Aleurodes, as some species of that genus appear to have the branching vein of Aleurodicus, owing to the presence of a deceptive fold. Altogether the work is a very valuable and timely one, and it is to be hoped that it will further the study of the Aleurodidæ, which it renders comparatively easy. It is, unfortunately, rather marred by numerous misprints.

T. D. A. Cockerell.

Scientific Results of H. M. S. "Thetis."[2] — The second part of the "Scientific Results of the Trawling Expedition of *H. M. S.* 'Thetis' off the Coast of New South Wales" is devoted to the higher Crustacea, by Mr. Thomas Whitelegge, zoölogist of the Australian Museum. As evidence of the richness of the fauna about Port Jackson, the author enumerates sixty-five species of invertebrates attached to or living upon a rock of about thirty pounds in weight, which was

[1] *Bulletin No. 8* (1900), Technical Series, Division of Entomology, Department of Agriculture, pp. 9–64.

[2] Scientific Results of the Trawling Expedition of *H. M. S. Thetis* off the Coast of New South Wales, etc., Pt. II. The Crustacea, Pt. i, by Thos. Whitelegge, *Mem. Australian Museum*, vol. iv, pp. 135–199, Pls. XXXII–XXXV. Sydney, 1900.

fished from a depth of thirty fathoms. After this preliminary we are prepared for the statement that the *Thetis* in its search for fishes obtained incidentally forty-nine species of Decapoda and Stomatopoda, of which twenty-one are additions to the fauna and ten are new. These last are *Pugettia mosaica*, *Chlorinoides waitei*, *Paramithrax tuberculatus*, *Pilumnus australis*, *Paguristes tuberculatus*, *Sympagurus diogenes*, *Glaucothoë hexagonata*, *Porcellano-pagurus tridentatus*, *Galathea* (*sp.* ?), and *Arctus crenatus*. The new species, as well as some of the old ones, are fully described, and illustrated by photographs and outline drawings. Among the most notable of the other additions to the fauna is *Pseudosquilla stylifera* (Milne-Edwards), which was known only from Chile and southern California. This species, by the way, is entitled to a new name, being different from *Squilla stylifera* of Lamarck, which Dr. Bigelow considers synonymous with *Pseudosquilla ciliata* (Fabricius ?) Miers. It is perhaps not remarkable that generic names that have been accepted for fifty or a hundred years, like Arctus, Eupagurus, and Squilla, should still be adhered to, though proven untenable.

The Temple Primers, which are intended to give condensed information on great subjects, open with a volume on Some Problems of the Day in Natural Science: An Introduction.[1] About half the book is given to first principles, including the definition, aim, and boundaries of science, the relations of science to philosophy, the senses as agents of the mind and their extension by artificial aids, the classification of the sciences, and the history and method of science. The remainder of the book is devoted to certain scientific problems of the day, such as the age of the earth, the ultimate constitution of matter, the origin of species, the coagulation of the blood, the function of nerve cells, and microphytology. In such restricted space so many problems can be touched on only superficially, and herein lies the chief defect of the volume. The book is neither better nor worse than its kind, but one is forced to ask why the impossible should be attempted.

P.

The Biological Bulletin. — Two issues of the *Biological Bulletin* were received in August. Vol. I, No. 4, dated July, 1900, contains: "Our North American Echiurids," by Charles B. Wilson; "Some General Features of the Metamorphosis of the Flag Weevil,

[1] Hill, Alexander. *The Temple Primers.* I. An Introduction to Science. London, Dent & Co., 1900. viii + 140 pp.

Mononychus vulpeculus Fabr.," by James G. Needham; "Notes on the Physiology of Regeneration of Parts in Planaria maculata," by C. C. Lemon; and "The Structure of the Eye of Scutigera (Cermatia) forceps," by Josephine Hemenway. Miss Hemenway does not refer to Packard's paper on the eye of *S. forceps*, and errs in stating that there is but one American Scutigera; other species have been described by Wood, Meinert, and Bollman.

No. 5, August, 1900, contains: "Abnormalities in the Cestode Moniezia expansa, I," by C. M. Child; and "A Description of the Male of Peripatus Eisenii Wheeler," by Augusta Rücker. Miss Rücker's paper is No. 5 of the *Contributions from the Zoölogical Laboratory of the University of Texas*, a series that already proves the wisdom of the university authorities in their choice of a director.

Notes. — The discovery of Moringuoid eels in American waters, by Dr. T. N. Gill and H. M. Smith (*Science*, Vol. XI, p. 973), is a matter of considerable interest. They find that the group is represented in the American tropics by four genera: Moringua, Aphthalmichthys, Leptoconger, and Gordiichthys.

Parts I–II, Vol. XXIII, of *Termeszetrajzi Füzetek* contain many papers of entomological interest. Among these mention may be made of Förster's "Odonaten aus New-Guinea, Part II," "Les espèces du genre Troides appartenant aux collections du Musée National Hongrois," by Horvath et Mocsáry, with three magnificent plates, and a "Catalogus Tabanidarum orbis terrarum universi," by Dr. Colomannus Kertész.

The giant hydroid *Brachiocerianthus* (*Monocaulus*) *imperator*, described by Allman from the *Challenger* collections, has again been taken in Japanese waters and minutely described by Miyajima (*Journ. Col. Sci. Imp. Univ. Tokyo*, XIII, Pt. II). In the long discussion and comparison with Mark's *B. urceolus* the reader is led to infer that the latter is also a Japanese species instead of being a tropical form from the extreme eastern Pacific. No indication is given as to the habitat, nor that it was taken by the Agassiz "Albatross" expedition of 1891 in the Panama district.

No. 4 of the fifth volume of the *American Journal of Physiology* contains the following articles: "On Uric Acid Formation after Splenectomy," by L. B. Mendel and H. C. Jackson; "On the Phosphorus Content of the Paranuclein from Casein," by H. C. Jackson; "Further Experiments on Artificial Parthenogenesis and the Nature

of the Process of Fertilization," by J. Loeb; and "Mammalian Smooth Muscle: The Cat's Bladder," by C. C. Stewart.

The concluding number of Vol. XVI of the *Journal of Morphology* contains: "The Development of the Coxal Gland, Branchial Cartilages, and Genital Ducts of Limulus polyphemus," by W. Patten and A. P. Hazen; "The Embryology of a Termite," by H. McE. Knower; "The Gastrulation of Amphioxus," by T. H. Morgan and A. P. Hazen; and "Photographs of the Egg of Allolobophora Fœtida," by K. Foot and E. C. Strobell.

BOTANY.

Text-Book of Botany.[1] — A copiously illustrated text-book of botany has been issued recently from the press of Baillière & Co., under the editorship of Felix Alcan, the object of which appears to be to supply a work of reference for university students, to which purpose it is well adapted. The treatment of the subject is logical and thorough, and generally in accord with the most recently ascertained facts, although adherence to an obsolete classification detracts somewhat from its usefulness. Under ten separate parts, the work presents a comprehensive view of plant life in all its phases, and discusses the place which plants occupy in nature. These are, respectively: (1) The Structure, Properties, and Products of the Body in general; (2) The Tissues; (3) The Structure of Members; (4) Growth of the Plant; (5) Nutrition; (6) Plant Associations — Symbiosis; (7) Movement; (8) Reproduction and Development; (9) Structure and Development of Cryptogamic Plants; (10) Ferments.

It is especially gratifying to find a recent work which takes a comprehensive view of the entire subject, and the chapters on Ferments and Plant Associations will be found particularly acceptable to students who wish to study these subjects in their proper relations to the general phenomena of plant life.

D. P. P.

Notes. — An expected upheaval of generic and higher botanical names begins in the June number of the *Allgemeine Botanische*

[1] Bebzung, Er. *Anatomie et Physiologie Végétales.* Paris, Baillière, 1900. 8vo, 1303 pp., 1700 figs.

Zeitschrift, with the first of a series of papers by Kuntze and von Post, and promises to be far-reaching if not final.

In *Science* for July 13, Dr. C. A. White contends for the use of the terms "epitropism," "apotropism," "hypercotyl," and "hypernasty," in place of the words "geotropism," "apogeotropism," "epicotyl," and "epinasty," now in common use.

Mr. Gannett's excellent paper on "The Forests of the United States" is separately published from the *Twentieth Annual Report of the United States Geological Survey.*

The flora of Ohio receives important consideration by Professor and Mrs. Kellerman in *University Bulletins* 27 and 28 of the botanical series of the Ohio State University.

C. A. Purpus is giving an account of the succulents of the La Salle Mountains of Utah, in current numbers of the *Monatsschrift für Kakteenkunde.*

An anatomical study of variegated leaves, by Mlle. Rodrigue, constitutes the greater part of No. 17 of the *Mémoires de l'herbier Boissier.*

Bulletin 107 of the Alabama Agricultural Experiment Station, devoted to cotton, contains, among other matters, chapters on the varieties of cotton, its improvement by hybridization and by selection, and its diseases, with a list of fungi recorded as growing on it, and a bibliography of its diseases.

The Rocky Mountain *Robinia neo-mexicana* is figured in *Curtis's Botanical Magazine* for July.

Bryophyllum crenatum, of Madagascar, a species related to the well-known life-plant, is figured in the *Revue Horticole* for July.

Mamillaria vivipara is figured in *Curtis's Botanical Magazine* for June.

Professor von Wettstein is publishing a study of certain North American gentians in current numbers of *Oesterreichische Botanische Zeitschrift.*

The well-known poisonous properties of *Primula obconica* form the subject of an article by Nestler in Heft V of the current volume of *Berichte der deutschen botanischen Gesellschaft.*

Helenium tenuifolium is figured in *Curtis's Botanical Magazine* for June.

Hesperaloe yuccæfolia, in the form which has been called *H. Engelmanni*, is figured in *Curtis's Botanical Magazine* for July.

A well-illustrated revision of the species of Bromus occurring north of Mexico, by C. L. Shear, is published as *Bulletin* No. 23 of the Division of Agrostology of the United States Department of Agriculture.

The folklore and history of the yew form the subject of a series of articles in the current numbers of *Prometheus*.

Professor Bessey contributes a revision of the tribes and a rearrangement of the genera of North American Diatomaceæ to Vol. XXI of the *Transactions of the American Microscopical Society*.

The dedication of Vol. LVII of *The Garden* is to Sir William Turner Thiselton-Dyer, and is accompanied by a short biographic sketch and an excellent portrait of the director of the celebrated Kew Gardens.

A portrait of Franchet accompanies Nos. 4 and 5 of the *Bulletin de la Société botanique de France* of the current year.

A portrait of the late Professor D. C. Eaton forms the frontispiece of the July number of *The Fern Bulletin*.

PALEONTOLOGY.

Fossil Cephalopods in the Timan. — Professor Holzapfel's[1] work should be read in connection with a recent memoir by Dr. J. M. Clarke ("Naples Fauna," *Ann. Rep. N. Y. State Geol.*, 1898), on the Intumescens fauna in America. In Dr. Clarke's work we see the fauna after it had immigrated to American waters, and in Professor Holzapfel's we see the fauna nearer to its origin. In New York the genus Manticoceras seems to be the prevailing one; in the Timan Gephyroceras is preëminent, while it is lacking in New York, but represented by Probeloceras Clarke. Those forms assigned by Clarke to Gephyroceras seem to agree with Timanites. The Intumescens fauna of the Timan agrees closely with that of the Urals, a number of species being identical.

[1] Holzapfel, E. Die Cephalopoden des Domanik im südlichen Timan, *Mém. Comité Géol.* (*Russie*), T. xii (1899), No. 3.

The New York fauna also shows a difference in the earlier appearance of Clymenia, which had not yet reached European waters.

Genuine Prolecanites occur in the Timan beds, but appeared later in America, in the Chemung, and became common first in the Kinderhook. An important note in Dr. Holzapfel's paper is that Karpinsky's genus Ibergiceras (*Gon. Tetragonus* Rœmer), which has been supposed to be the radicle of the Prolecanitidæ, is merely the young of *Pronorites cyclolobus* and came from the Carboniferous limestone of Iberg, not from the Intumescens beds, as has been thought heretofore.

J. P. S.

Russian Carboniferous Cephalopods. — In this paper the author[1] has given another important contribution to our knowledge of the cephalopod faunas of the Russian Carboniferous limestone. What is most interesting to American stratigraphers is that in this small collection are recognized a number of characteristic American species, most of which belong to the St. Louis-Chester horizon. This strengthens the probability that the lower part of the Moscow limestone belongs to the Lower Carboniferous and is the equivalent of the Visé formation of western Europe.

It should be noted, however, that the range of these species seems to be different from that in America. Thus *Nautilus chesterensis* Meek and Worthen in America is confined to the St. Louis-Chester horizon, and in Russia ranges up into the Coal Measures. The same thing is true of *Temnocheilus spectabilis* Meek and Worthen. *Brancoceras rotatorium*, as described by Tzwetaew, is correct generically, but the species is more robust than *B. rotatorium* or *B. ixion*, its American equivalent. Also in western Europe and in America this type occurs only in the Tournaisian, or Kinderhook, which gives additional weight to the improbability of specific identity.

J. P. S.

[1] Tzwetaew, Marie. Nautiloidea et Ammonoidea du calcaire carbonifère, *Mém. Comité Géol.* (*Russie*), T. viii (1898), No. 4.

NEWS.

After eighteen years of active work Professor J. C. Arthur resigns as editor of the *Botanical Gazette*, but will continue as one of the associate editors.

The fifth International Zoölogical Congress will be held in Berlin in 1901, under the presidency of Professor Karl Möbius.

Professor Carl Gegenbaur, of Heidelberg, has retired from active teaching.

Appointments: Dr. H. Ambronn, professor extraordinarius of botany in the University of Jena. — Dr. Walter B. Cannon, instructor in physiology in Harvard Medical School. — Dr. Fridrano Carava, associate professor of botany in the University of Cagliari. — Dr. George V. N. Dearborn, assistant professor of physiology in Tufts College. — Professor Dr. J. V. Deichmüller, custodian of the mineralogical museum in Dresden. — Dr. P. Dinse, curator of the Museum of Oceanography at Berlin. — Dr. Geo. P. Dreyer, professor of physiology in the medical school of the University of Illinois. — Dr. Charles L. Edwards, professor of natural history in Trinity College, Hartford. — Dr. J. W. Folsom, instructor in entomology in the University of Illinois. — Dr. A. Fritsch, professor extraordinarius of botany in the University of Prag. — Dr. C. Gagel, regional geologist of Prussia. — Dr. Walter E. Garrey, of Chicago, professor of physiology in Cooper Medical College, San Francisco, Cal. — Frederick O. Grover, professor of botany in Oberlin College. — Professor Leon Guignard, director of the school of pharmacy in Paris. — Sir George F. Hampson, first class assistant in the British Museum, Natural History. — Miss A. P. Hazen, assistant in zoölogy in Smith College. — Dr. Janni, professor extraordinarius of mineralogy and geology in the University of Basel. — Dr. P. B. Kennedy, of Washington, associate professor of botany and horticulture in the University of Nevada. — Dr. Charles A. Kofoid, assistant professor of histology and embryology in the University of California. — Mr. Thomas Large, assistant in the Illinois State Laboratory of Natural History, in charge of ichthyology. — Mr. John H. McClellan, instructor in zoölogy in the University of Illinois. — Dr. Albert P. Matthews,

instructor in physiology in Harvard Medical School. — Dr. Alfred G. Mayer, curator of natural science in the museum of the Brooklyn Institute of Arts and Science. — Dr. M. Meissner, custos of the zoölogical section of the museum of natural history in Berlin. — Mr. E. W. Morse, instructor in natural history in Harvard College. — Professor H. F. Osborn, vertebrate paleontologist to the geological survey of Canada. — Edmund Perrier, director of the Natural History Museum at Paris. — Professor Ferdinand von Richthofen, director of the Museum of Oceanography at Berlin. — Dr. M. Siedlecki, privat docent for zoölogy in Cracow. — Miss F. C. Smith, assistant in botany in Smith College. — Dr. Julia W. Snow, instructor in botany in Rockford College, Illinois. — Dr. Hermann Triepel, prosector in the anatomical institute of the University at Greifswald. — Dr. Lewis G. Westgate, professor of geology in the Ohio Wesleyan University. — Dr. S. R. Williams, professor of zoölogy in Miami University, Oxford, Ohio. — Alexander N. Winchell, professor of zoölogy and mineralogy in the Montana School of Mines, Butte, Montana. — Dr. E. Zimmermann, royal Prussian geologist.

Deaths: E. Allard, coleopterologist at Paris, in April. — Dr. Henry Beauregard, professor of cryptogamic botany in the Paris School of Pharmacy, in April. — Dr. Gustav Born, professor of anatomy and director of the embryological section in the University of Breslau, July 5, of heart disease, aged 49. — J. Lucius Caflisch, president of the Swiss Entomological Society, at Chur, March 9. — Dr. Corrado Tomassi Crudeli, professor of pathological histology at Rome. — Dr. Paul Hagenmüller, conchologist, at Marseilles, June 8. — Professor E. Kernstock, lichenologist, in Klagenfurt, April 14, aged 48. — Dr. Karl von Kraatz-Koschlau, mineralogist and privat docent in the University of Halle, at Para, Brazil, in May, of yellow fever. — Professor W. Kühne, director of the physiological institute of the University of Heidelberg, June 11, aged 62. — Edgar Leopold Layard, ornithologist, at Budleigh Salterton, Devon, England, aged 75. He was well known for his *Birds of South Africa*. — Carl Johann Lindeberg, botanist, in Alingsas, Sweden, May 4, aged 85. — G. Sherrif Tye, conchologist, at Birmingham, England, February 4. — Walter Percy Sladen, well known for his studies of echinoderms, at Florence, Italy, June 11. — Percy S. Selous, naturalist, at Greenville, Mich., April 7, from the bite of a moccasin.

PUBLICATIONS RECEIVED.

(Regular exchanges are not included.)

Atkinson, J. Winter Wheat. *Bull. Iowa Agr. Exp. Sta.*, No. 51. pp. 24–30. August. — Bioletti, F. T., and Ial Piaz, A. M. Bench-Grafting Resistant Vines. *Bull. Cal. Agr. Exp. Sta.*, No. 127. p. 38, 9 figs. — Bogue, E. E. An Annotated Catalogue of the Ferns and Flowering Plants of Oklahoma. *Bull. Okla. Agr. Exp. Sta.*, No. 45. p. 48. March. — Branner, J. C. Results of the Branner-Agassiz Expedition to Brazil. IV. Two Characteristic Geologic Sections on Northeast Coast of Brazil. *Proc. Wash. Acad. Sci.* Vol. ii, pp. 185–201, 9 figs. — Buffum, B. C. Alfalfa as a Fertilizer. *Bull. Wyo. Agr. Exp. Sta.*, No. 44. pp. 93–106, 3 figs. April. — Buffum, B. C. Alfalfa as a Hay Crop, etc. *Bull. Wyo. Agr. Exp. Sta.*, No. 43. pp. 47–91, 8 figs. March. — Buffum, B. C., and Fairfield, W. H. Some Experiments with Subsoiling. *Bull. Wyo. Agr. Exp. Sta.*, No. 41. pp. 1–21, 2 figs. November, 1899. — Cobb, J. N. The Sturgeon Fishery of the Delaware River and Bay. *Rept. U. S. Fish Com.*, 1899. pp. 369–380, plates 18–21. — Evermann, B. W. Descriptions of Two New Species of Darters from Lake Maxinkuchee. *Indiana Rept. U. S. Fish Com.*, 1899. pp. 363–367, plate 17. — Farr, Marcus S. Check List of New York Birds. *Bull. N. Y. State Museum*. Vol. vii, No. 33, pp. 198–409. — Fraps, G. S. The Digestibility of Some Non-Nitrogenous Constituents of Certain Feeding Stuffs. *Bull. North Carolina Agr. Exp. Sta.*, No. 172. pp. 49–80. May. — Gilbert, C. A. Results of the Branner-Agassiz Expedition to Brazil. III. The Fishes. *Proc. Wash. Acad. Sci.* Vol. ii, pp. 161–184. — Howard, L. O. Notes on the Mosquitoes of the United States, giving Some Account of their Structure and Biology, with Remarks on Remedies. *United States Department of Agriculture, Division Entomology. Bulletin No. 25.* p. 70, 22 figs. — Jenkins, O. P. Descriptions of New Species of Fishes from the Hawaiian Islands belonging to the Families Labridæ and Scaridæ. *Bull. U. S. Fish Com.*, 1899. pp. 45–65, 22 figs. — Jennings, H. S. Rotatoria of the United States with Special Reference to those of the Great Lakes. *Bull. U. S. Fish Com.*, 1899. pp. 67–104, plates 14–22. — Massey, W. F., and Rhodes, A. Gardening under Glass. *Bull. North Carolina Agr. Exp. Sta.*, No. 170. pp. 1–24. March. — Miller, G. S., Jr. Mammals collected by Dr. W. L. Abbott on Islands in the North China Sea. *Proc. Wash. Acad. Sci.* Vol. ii, pp. 203–246, 16 figs. — Palmer, T. S. Legislation for the Protection of Birds other than Game Birds. *United States Department of Agriculture, Division Biological Survey, Bulletin No. 12.* p. 94, 7 figs., 2 plates. — Palmer, T. S. A Review of Economic Ornithology in the United States. *Year-Book, Dept. of Agr. for 1899.* pp. 259–292, plates vi–viii. — Rathbun, Mary J. Results of the Branner-Agassiz Expedition to Brazil. I. The Decapod and Stomatopod Crustacea. *Proc. Wash. Acad. Sci.* Vol. ii, pp. 133–156. — Richardson, Harriet. Results of the Branner-Agassiz Expedition to Brazil. II. The Isopod Crustacea. *Proc. Wash. Acad. Sci.* Vol. ii, pp. 157–159,

4 figs. — RITTER, WM. E. Papers from the Harriman Alaska Expedition. II. Harrimania Maculosa, a New Genus and Species of Enteropneusta from Alaska, with Special Regard to the Character of the Notochord. *Proc. Wash. Acad. Sci.* Vol. ii, pp. 111–132, plate vii. — SMITH, J. C. Notices of Some Undescribed Infusoria from the Infusorial Fauna of Louisiana. *Trans. Amer. Micr. Soc.* Vol. xxi, pp. 87–96, plate vi. — TOURNEY, J. W. Practical Tree Planting. *United States Department of Agriculture, Division of Forestry, Bulletin No. 27.* 4 plates, 2 figs. — WHEELER, H. J., and ADAMS, G. E. The Needs and Treatment of the Warwick Plain and other Sandy Soils of Rhode Island. *Bull. R. I. Agr. Exp. Sta.*, No. 68. pp. 159–174. June. — WHEELER, H. J., and BOSWORTH, A. W. Feeding and Feeding Stuffs. *Bull. R. I. Agr. Exp. Sta.*, No. 64. pp. 103–124. March. — WHEELER, H. J., and TILLINGHAST. Effect of Liming upon the Relative Yields and Durability of Grass and Weeds. *Bull. R. I. Agr. Exp. Sta.*, No. 66. pp. 137–147, 11 figs. April. — WHEELER, H. J., and TILLINGHAST. Fertilizer Experiments with Potatoes. *Bull. R. I. Agr. Exp. Sta.*, No. 65. pp. 127–134. April. — WHEELER, W. M. The Free-Swimming Copepods of the Woods Holl Region. *Bull. U. S. Fish Com.*, 1899. pp. 157–192, 28 figs.

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CONTENTS

			PAGE
I.	A Singular Arachnid (Kœnenia Mirabilis Grassi) occurring in Texas	Professor W. M. WHEELER	837
II.	A New Myrmecophile from the Mushroom Gardens of the Texan Leaf-Cutting Ant	Professor W. M. WHEELER	851
III.	On the Variation of the Shell of Pecten Irradians Lamarck from Long Island	Professor C. B. DAVENPORT	863
IV.	Variations in the Crest of Daphnia Hyalina	MINNIE MARIE ENTEMAN	879
V.	Double Loxosomæ	Professor W. S. NICKERSON	891
VI.	Reviews of Recent Literature: *Zoölogy*, Notes on Recent Fish Literature, The "Tierreich" Sporozoa, Faune de France, Notes — *Botany*, Briefer Courses in Botany, Nicholson's Dictionary of Gardening, James's Practical Agriculture, Notes		897 905
VII.	Correspondence: Garman's Deep-Sea Fishes	Professor H. B. WARD	910
VIII.	Publications Received		911

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AMERICAN NATURALIST

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A SINGULAR ARACHNID (KŒNENIA MIRABILIS GRASSI) OCCURRING IN TEXAS.[1]

WILLIAM MORTON WHEELER.

IN 1886 Battista Grassi[2] described as the representative of a new order a remarkable arachnid which he found near the base of Mt. Ætna in the campagna of Catania, Sicily. Grassi's description was imperfect and seems to have excited little interest in his discovery till Dr. H. J. Hansen in 1893 collected a number of specimens of the same species in southern Italy (near Palmi and Scilla in Calabria) and together with Dr. W. Sörensen published a careful description of the external anatomy, with some good figures of the animal.[3]

During the past spring, while collecting specimens of Iapyx, Campodea, and Scolopendrella, in the vicinity of Austin, Texas, I

[1] *Contributions from the Zoölogical Laboratory of the University of Texas*, No. 8.

[2] I Progenitori dei Miriapodi e degli Insetti. Mem. V. Intorno ad un nuovo Aracnide Artrogastro (Kœnenia mirabilis) rappresentante di un nuovo ordine (Microthelyphonida), *Bull. d. Soc. entom. Italiana*, pp. 153–172. Anno 18. Firenze, 1886.

[3] The Order Palpigradi Thor. (Kœnenia mirabilis Grassi) and its Relationship to the other Arachnida, *Entomol. Tidskr.*, pp. 223–240. Årg. 18 H. 4, 1897. Taf. IV.

found a minute arachnid which at first sight resembled the whip-tailed scorpions (Thelyphonus), but on closer inspection proved to be something very different. Text-books were consulted in vain, with the single exception of Lang's *Vergleichende Anatomie*, which put me on the track of the Microthely-

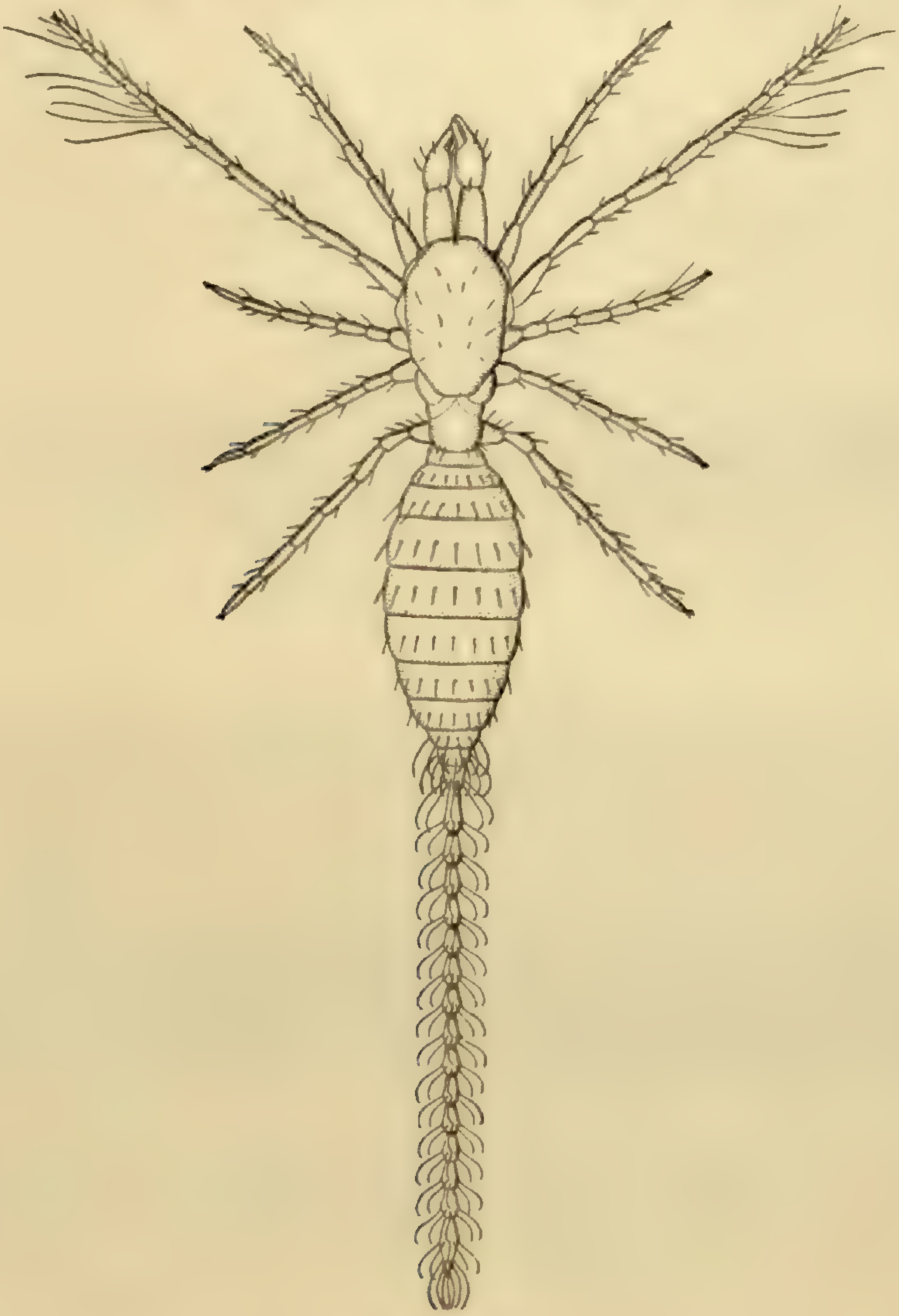

FIG. 1.

phonida of Grassi. Then, through the kindness of Drs. Hansen and Sörensen, I received a copy of their paper on *Kœnenia mirabilis*. To my surprise the Texan form proved to be identical with the Sicilian species!

In the following pages I shall consider, first, the external structure and systematic affinities of Kœnenia; second, its habits and habitat; and, third, its singular geographical distribution. If I repeat many of the statements in Hansen

and Sörensen's paper, this is because I have confirmed nearly all of their observations, published in a journal that may not be accessible to the reader, and because I am able to add a few facts of interest. An account of the internal anatomy, by Miss Augusta Rucker and myself, is reserved for future publication.

The observations of Grassi and Hansen and Sörensen refer only to the female Kœnenia, as the male was quite unknown to these investigators. In more than a hundred specimens I find only one which may, perhaps, be the male of this arachnid. To this I shall return in the sequel, after describing the female.

The general appearance of the female is correctly shown in Fig. 1, although in life the first pair of appendages, the chelicerae, have their chelæ bent down so that they are not visible from above, and the caudal filament, or flagellum, is turned up over the back, or at least carried obliquely upwards. The length of the body varies from .7 to 1.25 mm.; the length of the caudal flagellum nearly equals that of the body. The animal is of a translucent white color except for the blades of the chelicerae, which have the yellow tint of thickened chitin. The general chitinous integument is very thin and transparent, scarcely differing in thickness in the segmental and intersegmental, and on the dorsal and ventral regions of the body. The body and limbs are sparsely covered with bristles, which have a characteristic arrangement. They are delicately plumose under a high magnification.

The trunk proper consists of the head, thorax, and abdomen. The head, comprising at least four segments, as indicated by its four pairs of appendages, is covered dorsally with an elongate octagonal cephalic plate, or shield. This is broadest in the region of the coxæ of the third pair of limbs. It is abruptly declivous in front to the insertions of the chelicerae. There are no traces of eyes, but Hansen and Sörensen have discovered two pairs of minute sense organs "as if in compensation" for the lack of visual structures.[1] "The foremost of these couples is situated in the median line of the body and on

[1] *Loc. cit.*, pp. 230, 231.

the front of the head, close above the first pair of limbs (cheliceræ); it consists of two flat, lancet-shaped bodies, which by a common basal part are attached to the head, against which they are pressed. The second couple forms two blades, which are placed close up to the sides of the head above the coxæ of the second pair of limbs, and which, though deviating somewhat in shape, in quality very much resemble the first couple of blades; they turn, at least when in repose, horizontally forward and outward. As they are articulated to the head, it is not unlikely that they can move. Morphologically they are hairs." Hansen and Sörensen do not pretend to have demonstrated the sensory function of these structures.

The Danish investigators have also given an accurate account of the mouth of Kœnenia.[1] "It is simpler than in any other arachnid, nay, than in almost all other Condylopods, no limbs at all participating in its forming, and we are of opinion that in this respect the mouth of Kœnenia, simple and plain as it is, presents great interest. It has the shape of a downward sloping protruding knot, and its opening consists of a relatively large split extending not quite up to the base of the mouth eminence. Seen from below, this split is slightly crescent-shaped and curves towards the front. It is bordered by two flaps which along its margins are furnished with a rather strongly chitinized "list" or frame, which seems to become somewhat weaker towards the corners of the mouth. The foremost or uppermost of these flaps no doubt constitutes the organ which in other Arachnida one of us (William Sörensen) calls the labrum (or, when divided into two parts, the clypeus and the labrum), but which otherwise (according to the different authors) goes by rather varying names (rostrum, epistoma, camerostoma). . . . We entertain some doubts as to how the lower or hindermost flap is to be understood from a morphological point of view. So for the present we will call it *hypostoma*, as we consider this name morphologically tolerably indifferent. It is furnished outwardly with very tiny backward turning hairs placed somewhat less close together than those on the labrum. The labrum, as well as the hypostoma, is

[1] *Loc. cit.*, pp. 226, 227.

movable, so as to allow the mouth to open and close. The muscles, which, by the bye, we have not examined more closely, are very strong."

The thorax, which is quite distinct from the head, consists of two separate segments, each bearing a pair of limbs. In this respect Kœnenia resembles the Tartarides and Solifugæ, the only other arachnids with a bisegmental thorax.

The six pairs of limbs are, with the exception of the first pair, or cheliceræ, of a remarkably simple structure. Even the cheliceræ are of a primitive type, in that they consist of three joints. They are said by Hansen and Sörensen to "correspond entirely with the type appearing in the Opiliones," except in their minuter characters. The insertions of their long and powerful first joints are slightly to the sides of the mouth; a very significant fact, since in all the higher Arachnida these organs are definitely preoral. The second and third joints of each chelicera form a pair of pinchers. Each of these joints is furnished with a dense series of eight slender, pointed teeth.

The second to sixth pairs of appendages have essentially the same simple type of structure, although the pairs differ in length and in the number of joints. The formula of their lengths is as follows:

$$3 > 6 > 2 > 5 > 4.$$

The second pair have nine joints, the third twelve, the fourth and fifth each seven, the sixth eight joints. All the legs terminate in two claws and a curved pseudonychium. All are provided with a coxa, trochanter, and femur. The third to sixth pairs have a separate patella and tibia, but these two joints are represented by a single piece in the second pair. "The metatarsus is two-jointed in the second pair of limbs, four-jointed in the third pair, and undivided in the fourth, fifth, and sixth pairs." The "tarsus is three-jointed in the second and third pairs of limbs, one-jointed in the fourth and fifth, two-jointed in the sixth."[1]

Although the second to sixth pairs of limbs are all used in

[1] Hansen and Sörensen, *loc. cit.*, p. 230.

running, the very long third pair are usually held aloft like antennæ when the animal is not disturbed and is moving about slowly. Some of the metatarsal and tarsal joints of this pair of appendages are provided with very long, delicate hairs of uniform thickness throughout. They are very probably sense-hairs (possibly auditory in function, as suggested by Hansen and Sörensen).

Between the insertions of the legs the ventral surface of the head and thorax presents a series of sternal plates to which the Danish arachnologists have called particular attention. The lower surface of the head has two of these plates, a larger anterior one just behind the mouth and corresponding to the second and third pairs of appendages, and a smaller piece corresponding to the third pair of limbs. Farther back there are two more sternal plates, one to each of the thoracic segments. The condition of the sternal apparatus of the head is emphasized "as a curiosity, as it is quite unique in Arachnida, which otherwise show no trace of independence in the segments constituting the head." [1]

The abdomen is elongate elliptical in outline, without any traces of dorso-ventral flattening, and consists of eleven segments. The first is short and narrow, and on this account may be readily overlooked. The ninth, tenth, and eleventh are very much narrower than the preceding segments. The last bears the anus on its ventral surface. To its posterior surface the caudal flagellum is attached. The dorsal surfaces of the abdominal segments each presents a single row of bristles which are inserted rather far apart and near the middle of their respective segments.

Hansen and Sörensen have failed to give a satisfactory account of the ventral surface of the abdomen. The conditions are not so easily studied as might at first sight be supposed. Nor am I certain that my analysis of this region is complete, as my specimens differ considerably in the clearness with which they show certain structures, notably the complicated valves surrounding the genital orifice. I am of the opinion that segments two to six are each provided with a

[1] Hansen and Sörensen, *loc. cit.*, p. 226.

pair of appendages, presumably the serial homologues of the cephalic and thoracic limbs. The appendages of the second and third segments have come together in the median line to form four peculiar setigerous valves surrounding the genital orifice lying between these segments. The shape of the valves and the characteristic arrangement of their bristles are shown in Fig. 2. The anterior pair, which I regard as the appendages of the first segment, are arcuate and closely applied to each other in the mid-ventral line. Their posterior edges are raised on either side into six papillæ, each capped with a strong bristle. The posterior pair are flattened and enclose the orifice of the chitinous genital conduit between their bases. Their posterior edges are fringed with a series of graduated bristles. A profile view of the abdomen shows that the genital duct runs forward into the second abdominal segment. Thus Kœnenia would seem to agree with other Arachnida in having the reproductive orifice on the second abdominal segment.

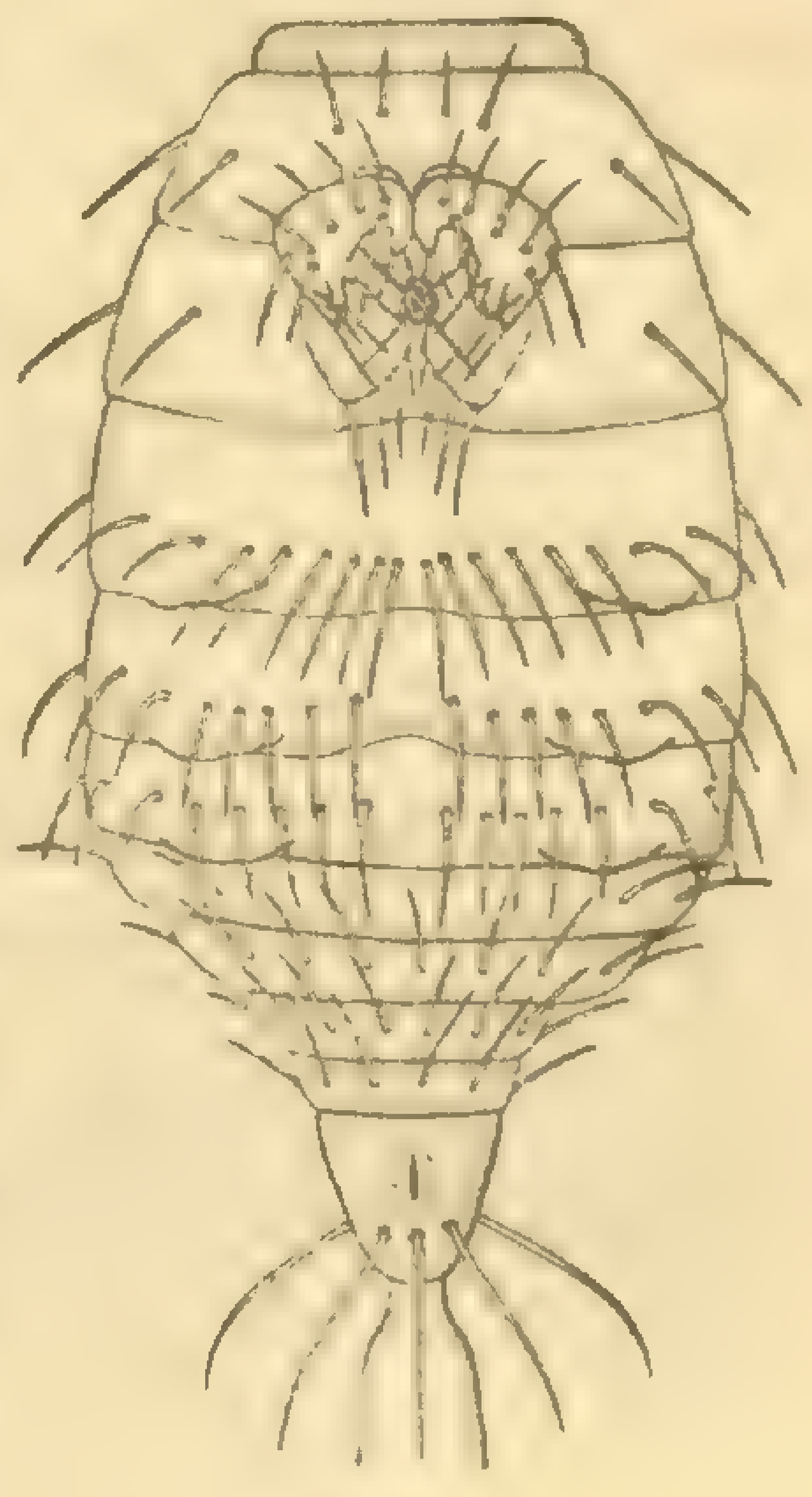

FIG. 2.

The ventral portions of the fourth, fifth, and sixth segments are nearly alike in structure. Each is provided with a single row of powerful bristles, which, though more or less interrupted in the median line, are nevertheless far more closely aggregated than those on the dorsal surface of the corresponding segments. On either side near the posterior edge of the segment there is a flap, the exact outline of which is not so clear as represented in Fig. 2. In many specimens a very delicate sac may be found evaginated from under the flap on all three segments. These sacs are in all probability lung-books. They appear to be the only respiratory organs of Kœnenia, apart from the delicate integument, which, in so small an animal, must of itself nearly suffice for respiratory purposes. I have had no better success than Grassi and Hansen and Sörensen in finding any traces of tracheæ. If I am correct in regarding the above-described sacs as lung-books,

they must represent these organs in an extremely simple form, in a form, moreover, which strongly suggests their origin from invaginated appendages serially homologous with those of the cephalic and thoracic segments. Whether these delicate organs may be everted by blood pressure and withdrawn by muscular action, like the collophoral tubes of the Collembola and the eversible sacs of Thysanura (Machilis, *e.g.*), remains to be determined. If this is the case, the hedge of bristles in front of the lung-book flap would seem to have a definite protective function.

Another lacuna in the observations of Hansen and Sörensen refers to the caudal flagellum. According to Grassi this organ contains altogether thirteen or fourteen joints. The greatest number of joints present in any of Hansen and Sörensen's specimens was nine, and on Grassi's authority they have added five joints of the same structure in fainter outline to the flagellum in their Fig. 1, Taf. IV. The flagellum is very easily broken, even after the animals have been transferred entire to alcohol, so that in upwards of a hundred specimens I found the structure complete in only ten individuals. Eight of these had fifteen, one had fourteen, and one had only eleven joints in the flagellum. There could be no doubt that in all these cases the flagellum was complete, as the terminal joint ends in a point and is longer and of a different shape than the preceding joints (Fig. 1). In my specimens, joints one to eleven have the structure described by Hansen and Sörensen.[1] Each "is fusiform, as if composed of two truncate cones, one long, the other short, united at their base, and adorned with two rings of backward-turning setiform hairs. In the foremost ring, situated on the widest part of it, we find, where we have been able to count the number, eight long, slightly curved hairs; in the hindmost terminal ring, sixteen much shorter, thinner, and less curved ones." In my specimens the posterior circlet of appressed bristles is lacking on the twelfth, thirteenth, and fourteenth joints. The terminal joint is twice as long as any of the preceding, fusiform in shape, and provided with two circlets of long, curved bristles.

[1] *Loc. cit.*, p. 233.

So much for the description of the female of *Kœnenia mirabilis.* From this description a single specimen among my material differs so much that I am compelled to regard it either as the hitherto unknown male of Grassi's species or as an entirely new form. I choose the former alternative, since the differences are confined, so far as I am able to determine, to size, the structure of the genital valves, and the caudal flagellum. The specimen is only .5 mm. in length. The genital valves, seen in profile in Fig. 3, certainly have a very different shape from those of the female, although I am unable to form a clear conception of their structure. The caudal flagellum, represented in Fig. 4, consists of only six joints of gradually decreasing size. There are only six bristles in the larger circlet of each joint, and the smaller circlet of appressed bristles is present only on joints one to four. In addition to the larger bristles, joints three to six have a number of minute scattered hairs. Of course we may consider the possibility of an abbreviated regeneration of the easily broken caudal flagellum, both in this specimen and in the case of the two above-mentioned females, with eleven and fourteen joints respectively. I am certain, however, that this six-jointed flagellum cannot represent merely a young stage in the development of the fifteen-jointed flagellum of the female, for I have seen several young female specimens of about the same size (.5–.7 mm.) with a large portion of the caudal filament, eight to ten joints, of the normal form.

FIG. 3.

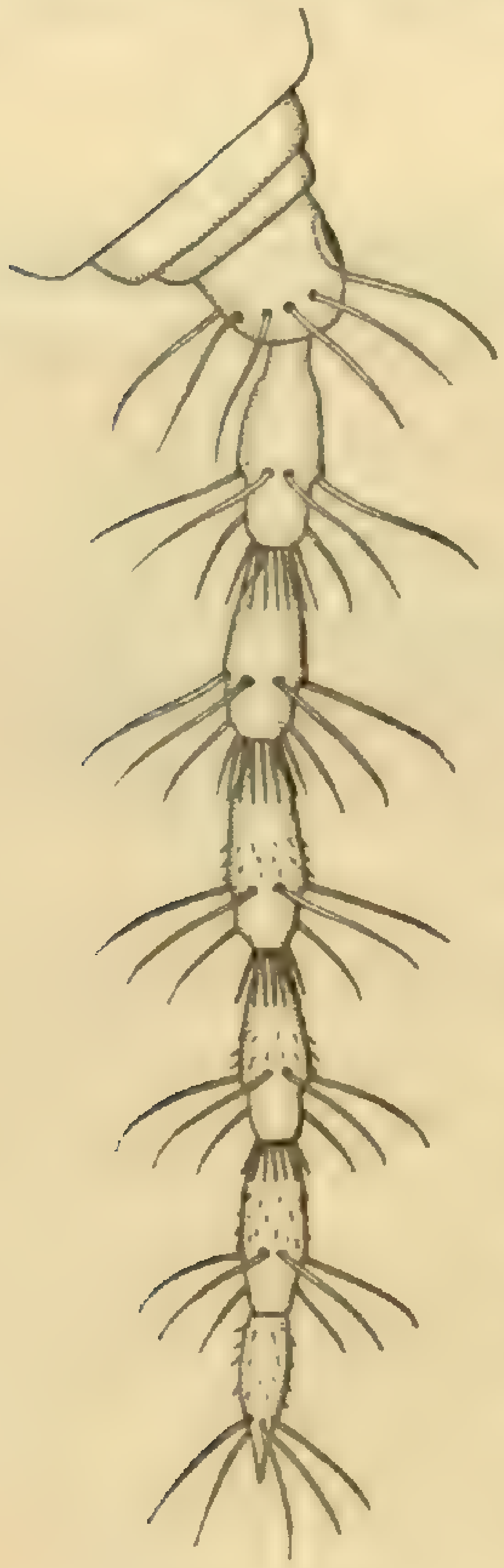

FIG. 4.

From the description of Kœnenia we pass to a consideration of its affinities. Grassi established it as the type of a distinct arachnid order, which he designated as *Microthelyphonida*, a term somewhat lengthy, to be sure, but nevertheless suggesting the small size of the

animal and its unmistakable resemblance to Thelyphonus, the whip-tailed scorpion. Without differing to an appreciable extent from Grassi in his conception of the taxonomic importance of Kœnenia, Thorell[1] has seen fit to change the name of the new order to *Palpigradi.* Hansen and Sörensen have adopted this name and have abandoned Grassi's. It would seem, however, that notwithstanding the aptness and brevity of Thorell's name, it can hardly be accepted without violating the law of priority in nomenclature.

Hansen and Sörensen make it clear that the Microthelyphonida are far removed from all the other orders of Arachnida, excepting the Pedipalpi. On this subject I cannot do better than to quote *in extenso* the opinion of these competent arachnologists[2]:

"While it is easy enough to show differences between Palpigradi and Scorpiones, Chelonethi, Solifugæ, Opiliones, Araneæ, and Acari, we confess that we should find great difficulty in detecting resemblances to these orders, except in the fact that they are all arachnids. Though, indeed, the order Pedipalpi is poor in species, its two suborders, Amblypygi (with the family Phrynoidæ) and Uropygi (with its tribes Oxopoei, the family Thelyphonoidæ, and Tartarides), exhibit great mutual differences, for instance, in the structure of the mouth. And, indeed, it is the most central of the orders of Arachnida; through Amblypygi it reveals decided affinity with Araneæ; through Tartarides with Palpigradi; and through Oxopoei, to a minor degree, with Scorpiones and Chelonethi. As stated by Thorell several years ago, Opiliones and Acari are closely related to each other, but we confess that these two, as well as the Solifugæ, must still be said to stand far apart from the others.

"As far as we can see, the most essential external characters of the different orders of Arachnida must be taken from the structure of (1) the mouth, (2) the antennæ (first pair of limbs), (3) the other limbs, and (4) the (real) number of the abdominal segments.

[1] Pedipalpi e Scorpioni dell' Arcipelago Malese, *Ann. d. Mus. Civ. d. Stor. Nat. di Genova*, vol. vi, pp. 327–428, 358, 2d Ser. Genova, 1888.

[2] *Loc. cit.*, pp. 236–338.

"1. The mouth of the Palpigradi (as we have already pointed out above) differs from that of all other Arachnida, nay, from that of almost all other Condylopods, in being formed exclusively by the labrum and the hypostoma. And even if Kœnenia did not offer other characteristics, this circumstance would, to our eyes, be sufficient to set it aside as an independent order.

"2. The antennæ (cheliceræ) of the Palpigradi are three-jointed, and the two distal joints form a pair of pinchers with horizontal movement of the third joint against the prolongation of the second. In this structural feature Kœnenia agrees with the Opiliones and Scorpiones, and differs most decisively from the Pedipalpi, in which the antennæ are two-jointed and do not form real pinchers.

"3. The five remaining pairs of limbs are similar in all the most essential features, as none of the anterior three pairs (second, third, and fourth) are provided with maxillary lobes which help to form the mouth, but are developed exclusively as organs of movement, like the two posterior pairs of limbs which in all arachnids, where they are found at all, are merely instruments of movement. Therefore the foot (tarsus *s. lat.*) in all five pairs is divided into a metatarsus and a tarsus (*s. str.*). In the four posterior pairs of limbs patella and tibia are well developed, while in the second pair only one single joint is present.

"4. The abdomen consists of eleven segments, which are not divided into dorsal and ventral plates. In the Pedipalpi it consists of twelve segments, which (except the three hindmost ones in the Uropygi) are divided into a dorsal and a ventral plate. (Only in Amblypygi and Tartarides the first ventral plate is very sparingly chitinized.)"

The relationship of Kœnenia to other arachnids through the central group of the Pedipalpi is comparable to the relationship of the Thysanura (Campodea, Iapyx, Lepisma, *e.g.*) to other insect orders through the Orthoptera (including Dermaptera). In fact, Kœnenia, with its simple and generalized organization, reminds one of such phylogenetically important types as Polygordius, Campodea, Scolopendrella, Amphioxus, and Myxine. Like these animals, it undoubtedly combines in its organization

many simple ancestral characters with others, which, like the reduction or absence of eyes, tracheæ, etc., may be interpreted as the effects of degeneration. Till the internal structure of Kœnenia has been studied and compared with that of other arachnids, it is hardly possible to make more precise statements than the above concerning its phylogenetic relationships.

The statements made by Grassi and Hansen and Sörensen concerning the conditions under which Kœnenia lives in Sicily and southern Italy may be repeated almost verbatim for the Texan specimens. I have found them most abundant along the margin of a cedar thicket on a rocky hill (altitude about 700–800 feet), only a few minutes' walk from the campus of the University of Texas. They occur under stones rather deeply imbedded in the ground but easily overturned. The earth under these stones is of a very definite degree of moisture, which one soon learns to recognize when searching for specimens. The animals are found crawling over the surface of the stone, very rarely on the impressed soil. Sometimes four or five will be found on a single stone. They are very agile and easily escape into some crevice or under the particles of earth adhering to the stone. They are most easily captured, as Hansen and Sörensen have shown, by means of a fine brush dipped in alcohol.

In Europe Kœnenia was found associated with Iapyx, Campodea, Pauropus, and Scolopendrella. In Texas it is associated with the very same series of forms, excepting Pauropus, which I have not yet seen in this locality. I am inclined to believe that the arachnid feeds on the eggs of Campodea or Iapyx. I infer this from the fact that the intestine and its short diverticula are always filled with something very much like the yolk-bodies of an arthropod egg. Moreover, the Kœnenia was most abundant where the very young Campodea and Iapyx lived in greatest numbers.

The association of a group of forms like Kœnenia, Iapyx, Campodea, and Scolopendrella — all very small, primitive, and synthetic types, and all devoid of pigment and visual organs — in two localities so widely separated as Sicily and Texas, is of

considerable interest from the standpoint of ecology and geographical distribution. Although there is an unmistakable general similarity, due to similarity in climate and soil, between the southern European and the Texan faunas, this does not extend to identity of species in any case of which I am cognizant, except that of Kœnenia. One is at first tempted to suppose either that the arachnid is a native of Texas (and possibly also of Mexico and the West Indies) and has been introduced into Sicily and southern Italy with the century plant (*Agave*) and the prickly pear (*Opuntia*), or that, conversely, the arachnid has been introduced into America from Europe.[1] It would seem, however, that we cannot accept either of these alternatives, but are forced to the conclusion that Kœnenia is indigenous to both continents on account of the associated forms, for we can hardly assume that the species of Iapyx, Campodea, and Scolopendrella have also been imported.[2] It is certainly more reasonable to suppose that all these forms have a wide and disconnected geographical distribution as relicts of a very ancient fauna which have survived, like many cave forms (*e.g.*, the singular blind Menobranch Amphibians, Proteus and Typhlomolge), because they have inhabited conditions subject to little or no change during enormous periods of time. A striking instance analogous to that of Kœnenia has recently been brought to light in the form of a very primitive Thysanuran, *Projapyx stylifer*. This species, an Iapyx-like insect, with

[1] These plants, introduced since the discovery of America, are now so widely distributed in southern Italy that they form an essential part of the landscape. In Munich, several years ago, I saw a fine panorama representing imperial Rome in the days of Constantine. In this painting the artist, who had evidently studied the modern Italian landscape, had been misled into the amusing anachronism of filling out a corner of his canvas with clumps of Agaves and Opuntias! The above-suggested introduction of Kœnenia into Europe gains slightly in probability from the fact that a species of Schizonotus, a genus of minute Tartarids inhabiting Ceylon and Venezuela and somewhat resembling Kœnenia in structure and habits, has been introduced into Europe in connection with exotic plants (*teste* Pocock. The Geographical Distribution of the Arachnida of the Orders Pedipalpi and Solifugæ, *Natural Science*, vol. xiv, No. 85, March, 1899, pp. 213-231, 217).

[2] The American species of these Symphyla and Thysanura are certainly very similar to the corresponding European forms, and may yet be proved to be identical in the light of study as thorough as that which has been devoted to the taxonomy of some other groups of insects.

eleven-jointed cerci in the place of the more specialized anal forceps, was discovered by O. F. Cook in Liberia. Very recently the same form was taken at Federacion in the Argentine Republic by Silvestri.[1]

COLEBROOK, CONN., August 14, 1900.

[1] Anche *Projapyx stylifer*, O. F. Cook, nella R. Argentina. Nuovo genere di Polyxenidæ, *Zool. Anzeiger*, Bd. xxiii, Nr. 609, March 5, 1900, pp. 113, 114.

A NEW MYRMECOPHILE FROM THE MUSHROOM GARDENS OF THE TEXAN LEAF-CUTTING ANT.[1]

WILLIAM MORTON WHEELER.

On the 10th of April last, with the assistance of Messrs. A. L. Melander and C. T. Brues, I excavated a large nest of leat-cutting ants (*Atta fervens* Say), situated in a piece of woodland a quarter of a mile from the University of Texas. The large burrows, nearly an inch in diameter, were found to extend down to a depth of from three to five feet and to open into large chambers, some of which were fully ten inches across and five to eight inches high. A few of these chambers were traversed by the roots of a large cedar, in the shade of which the ants had dug their formicary. Descending into the pit we had dug, and braving the attacks of tens of thousands of infuriated ants, we soon discovered the objects of our search — the mushroom gardens heaped up on the floor, or, more rarely, enveloping, as aërial or "hanging" gardens, the roots that extended across the chambers.

The gardens were hastily extracted — I say hastily because putting one's hand into one of these chambers is like grasping the handles of an electric machine, so valiantly do the ants defend their property. The material, reeking with an odor like that of stale honey, was placed in large glass jars. These had to serve as artificial nests, as nests of the Lubbock and Janet pattern were obviously not suited to these aberrant ants. By the following day the ants had completely rebuilt their gardens on the bottoms of the jars.

These gardens proved to be very similar to those so carefully described and figured by Möller[2] for several South American species of Atta (*A. discigera* Mayr., *A. hystrix* Latr., *A. coronata*

[1] *Contributions from the Zoölogical Laboratory of the University of Texas*, No. 9.

[2] *Die Pilzgärten einiger südamerikanischer Ameisen.* Jena, Gustav Fischer, 1893.

Fabr., and *A. Mölleri* Forel). Möller has described how the ants cut and bring the large pieces of leaves into their cellars, then cut them into smaller fragments, and finally com-

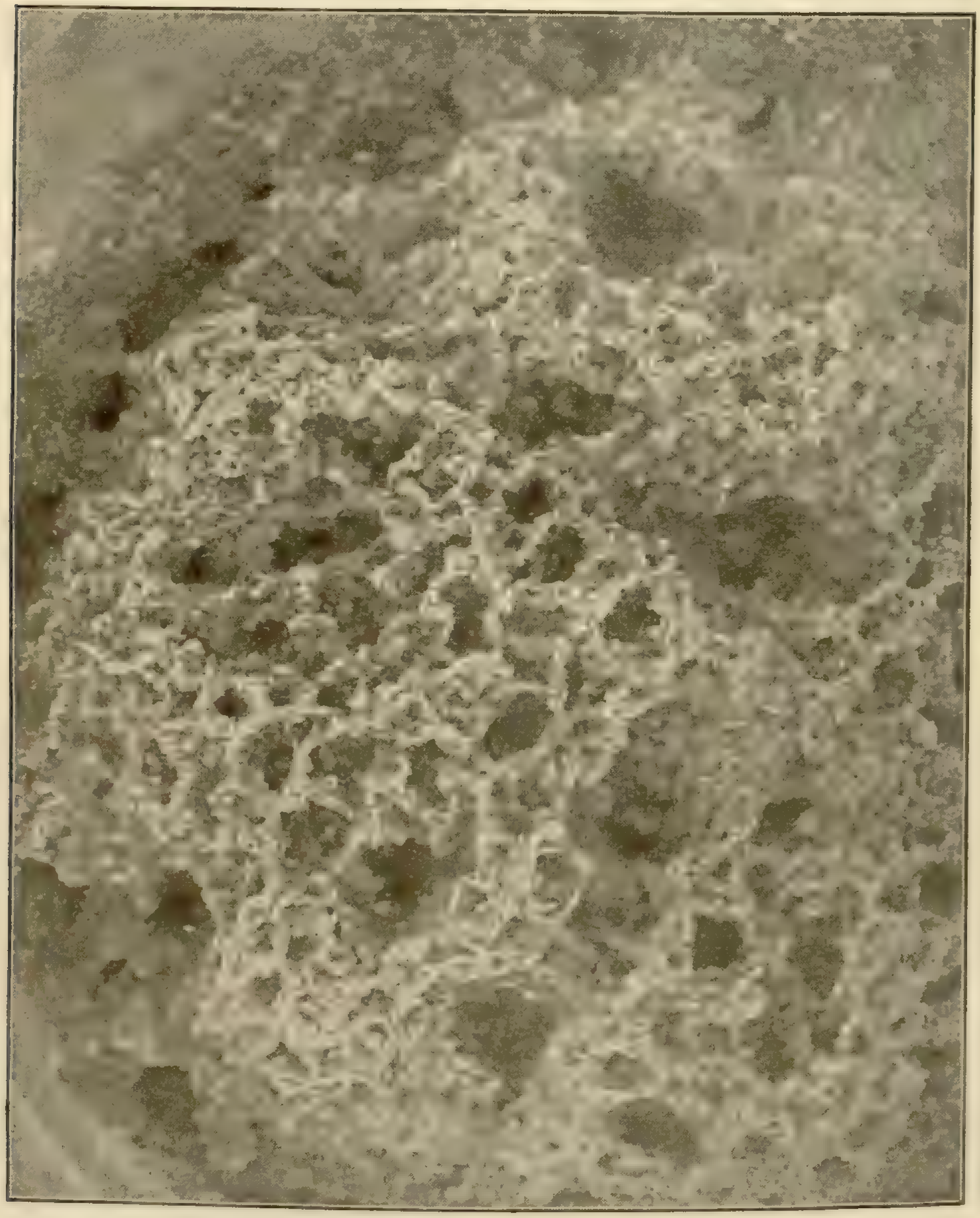

FIG. 1. — Mushroom garden of *Atta fervens* Say.

minute these still further till they form a flocculent greenish-brown pulp.[1] This pulp is heaped up and soon becomes invaded

[1] *Atta fervens*, like other species of the genus, is not fastidious in its choice of the material to be used as a soil for its gardens. Almost any vegetable substance will answer this purpose. In October, 1899, I saw a colony busily engaged collecting caterpillar excrement which had dropped from the overhanging foliage of a large sycamore. Several months later I found a large colony near the same spot marching in long procession, conveying big grains of cracked corn which

by the mycelium of a fungus (*Rozites gongylophora*). The mycelium is kept aseptically clean — *i.e.*, free from all other species of fungi and even from bacteria — and induced to grow in an abnormal way by bringing forth minute swellings which

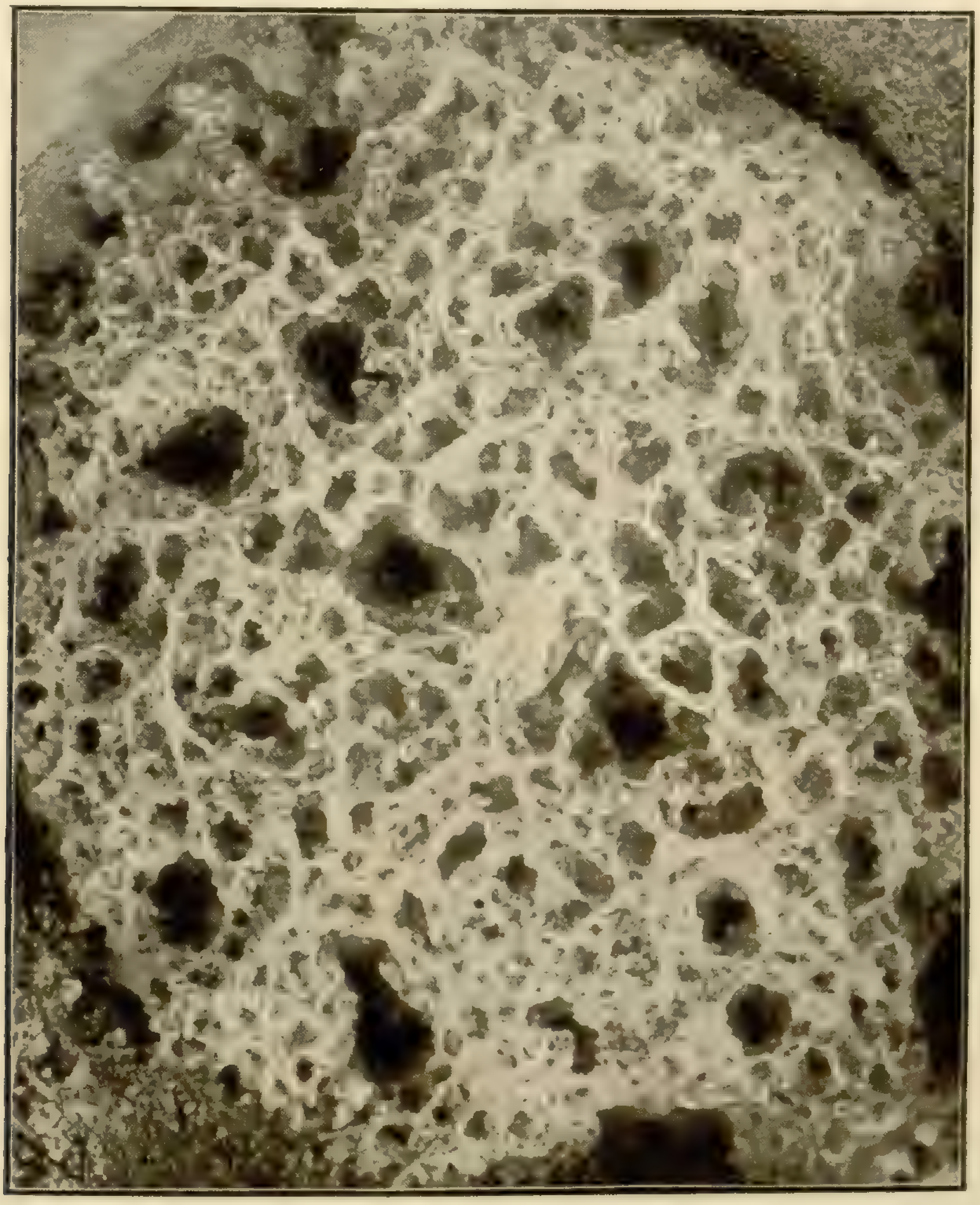

FIG. 2. — Mushroom garden of *Atta fervens* Say.

constitute the only food of the ant colony. Möller likens these swellings to the "Kohlrabi" of the German kitchen gardens.

they had filched from a mill near their nest. Sometimes they prefer to collect seeds or young flower-buds. In winter, when the leaves have fallen from all the trees except the live oaks and cedars — trees which the Attas avoid, probably because the leaves offer too much resistance to their mandibles — they garner the young leaves of the sorrel and lupine. At such times, especially when the landscape is flooded with the brilliant Texan sunshine, one may, perhaps, not inappropriately compare the ant procession with a procession of "Sunday-school children carrying banners" (McCook, On the Architecture and Habits of the Cutting Ant of Texas (Atta fervens), *Proc. Acad. Nat. Sci. Phil.*, pp. 33–40, 1879).

More recently Forel has studied the habits of two other species (*Atta cephalotes* L. and *A. sexdens* L.) in Colombia.[1] He seems to have given some attention to the rôle performed by the different casts of worker ants — casts which are also represented in our *Atta fervens* — in this process of collecting and comminuting the leaves and in cultivating the mushroom. At p. 31 he says: "The largest workers (soldiers) triturate the leaves and defend the nest. They draw blood when they bite. The indigenes are said to use these insects for closing wounds. They induce them to bite the two lips of the wound and thereupon sever the bodies from the heads, which then serve as a suture. The medium-sized workers cut the leaves from the trees, while in the nest the workers of the minim cast are forever clipping the threads of the mycelium of the Rhozites, which then develops the 'Kohlrabi,' on which the ants feed."

The shape of a mushroom garden is that of a discoidal sponge. On its upper surface the ants pile up the flocculent vegetable débris, threaded in all directions with fungus hyphæ, in the form of thin, vertical, anastomosing plates, so that as much surface as possible is exposed to the atmosphere of the chamber. This atmosphere must contain a great amount of carbon dioxide and a very small amount of oxygen. The peculiar appearance of the surface of two large gardens is shown in the photographs (Figs. 1 and 2, about ¼ the natural size). Although these gardens of *Atta fervens* closely resemble those of the South and Central American species observed by Möller and Forel, I have seen fit to figure them, both because Möller's work is out of print and may not be readily accessible to the reader, and because, to my knowledge, the gardens of our Texan leaf-cutter have not been figured heretofore. The ants leave several tubular or funnel-shaped openings (clearly shown in the figures), varying in diameter, and extending down into some chambers excavated in the base of the vegetable mass. In these chambers lives the huge queen of the colony, — an insect nearly an inch long, — the newly fledged males and virgin queens, together with the larvæ, pupæ, and attendant ants.

[1] *Biologia Centrali-Americana Hymenoptera.* Formicidæ (1899–1900), pp. 31 *et seq.*

The whole mushroom garden swarms with workers, representing all the different casts so characteristic of the genus Atta. The big-headed soldiers — like "Brownie" police officers — stalk about slowly over the surface of the comb, descending from time to time into the interior, as if to make sure that the great family is properly attending to its multifarious occupations, while thousands of minims keep moving about through the meshes of the mycelium, weeding the garden. In the presence of these varied activities and instincts one has a feeling of regret that all "anthropomorphism" is now to be banished from the study of ant life, and that we are asked to look at all this elaborate division of labor as nothing but an agglomeration of machine-like "reflexes."[1]

It is natural to suppose with Wasmann[2] that the vast amount of comminuted and decomposing vegetable matter collected by the leaf-cutting ants as a soil, or culture medium for the growth of their mushroom diet, would form a most favorable resort for a great number of myrmecophiles. Nevertheless, comparatively few of these symbiotic animals have been taken up to the present time. Besides the amphisbænians, which, though often found in the nests of the tropical Attas,[3] may not even be myrmecophagous, I find mention of comparatively few species in the literature. These include the following histerid beetles taken in the nests of *Atta fervens* in Mexico and enumerated in Wasmann's very useful *Verzeichnis*[4]: *Philister rufulus* Lewis, *Hister* (?) *costatus* Mars, *Reninus Salvini* Lewis, and *Carcinops* (?) *multistriata* Lewis. Belt[5] saw a species of "Staphylinus" in the Atta nests of Nicaragua, and Wasmann[6]

[1] See Bethe, Dürfen wir den Ameisen und Bienen psychische Qualitäten zuschreiben, *Arch. f. d. gesam. Physiologie*, Bd. lxx (1898), pp. 15–100, Taf. I u. II, 5 text-figs.; and Bethe, Noch einmal über die psychischen Qualitäten der Ameisen, *ibid.*, Bd. lxxix (1900), pp. 39–52.

[2] Die Ameisen- und Termitengäste von Brasilien, *Verhandl. d. k. k. zool. bot. Gesell.*, pp. 2–46, Wien, Jahrg. 1895.

[3] See Bates, *The Naturalist on the River Amazons*, London, 1876, pp. 51 and 52; Brent, Notes on the Œcodomas, or Leaf-Cutting Ants of Trinidad, *Amer. Nat.*, vol. xx (1886), pp. 123–131, No. 2; and Wasmann, *loc. cit.*, p. 9.

[4] *Kritisches Verzeichnis der myrmekophilen und termitophilen Arthropoden.* Berlin, Felix Dames, 1894.

[5] *A Naturalist in Nicaragua*, p. 84.

[6] Die Ameisen- und Termitengäste von Brasilien, *loc. cit.*

mentions two species of Aleochara and an Atheta found in the entrances to the nests of *Atta sexdens* L. at San Paolo, Brazil.

This short list of myrmecophiles led us to sift with considerable care the gardens of the nest we excavated. The result was a single species of myrmecophile, but this appeared in considerable numbers — more than seventy specimens being taken from three of the large gardens — and proves to be a cockroach (Blattid) of very small size and peculiar structure. With the exception of four males and two females, all the specimens are immature. The species appears to be undescribed, and as it does not belong to any genus of which I can find an account, I propose to describe it as the type of a new genus under the name of *Attaphila fungicola.*

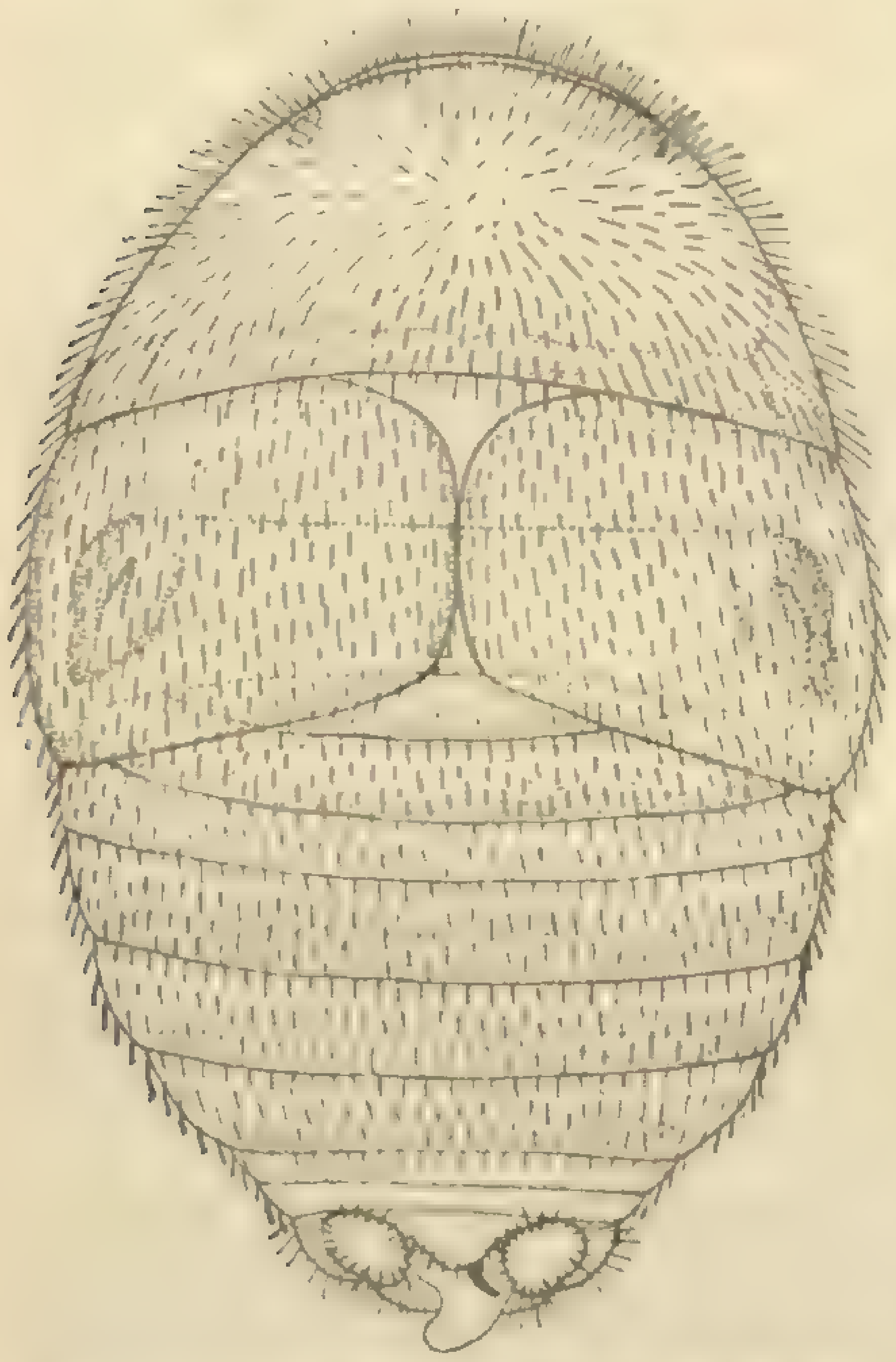

FIG. 3. — *Attaphila fungicola* n. sp., male, dorsal aspect.

In the artificial nests above mentioned the little cockroaches were frequently seen moving in and out of the tubular perforations in the vegetable mass. Occasionally one of them would mount a huge soldier that was slowly patrolling the surface of the garden, and ride about on its back or enormous head for minutes at a time. The ant did not appear to be in the least annoyed by this performance, nor did any of the other ants pay the slightest attention to the cockroaches when they were encountered in the passages. It is probable that Attaphila, like the ants, feeds on the modified hyphæ of the fungus. This is indicated by the fact that the intestines of several dissected specimens contained a whitish substance which may be the remains of the masticated mycelium. If this supposition proves to be correct, the relationship between the ants and the cockroaches is of a peculiar character. It is, in fact, a kind of myrmecoclepsy, or thieving. As the cockroaches eat the fungus cultivated by the ants for their own consumption, this kind of myrmecoclepsy may be said to differ from the typical form

exhibited by the Thysanuran Lepismina and the mite Antennophorus. In these cases, as Janet has shown in an excellent paper,[1] the guest steals some of the liquid food while it is passing from the mouth of one ant (*Lasius umbratus mixtus* Nyl.) to that of another.

Before passing to a more detailed description of Attaphila, attention may be called to a few of its structural and taxonomic peculiarities:

1. Up to the present time a genus of diminutive crickets (Myrmecophila) has comprised the only known myrmecophiles

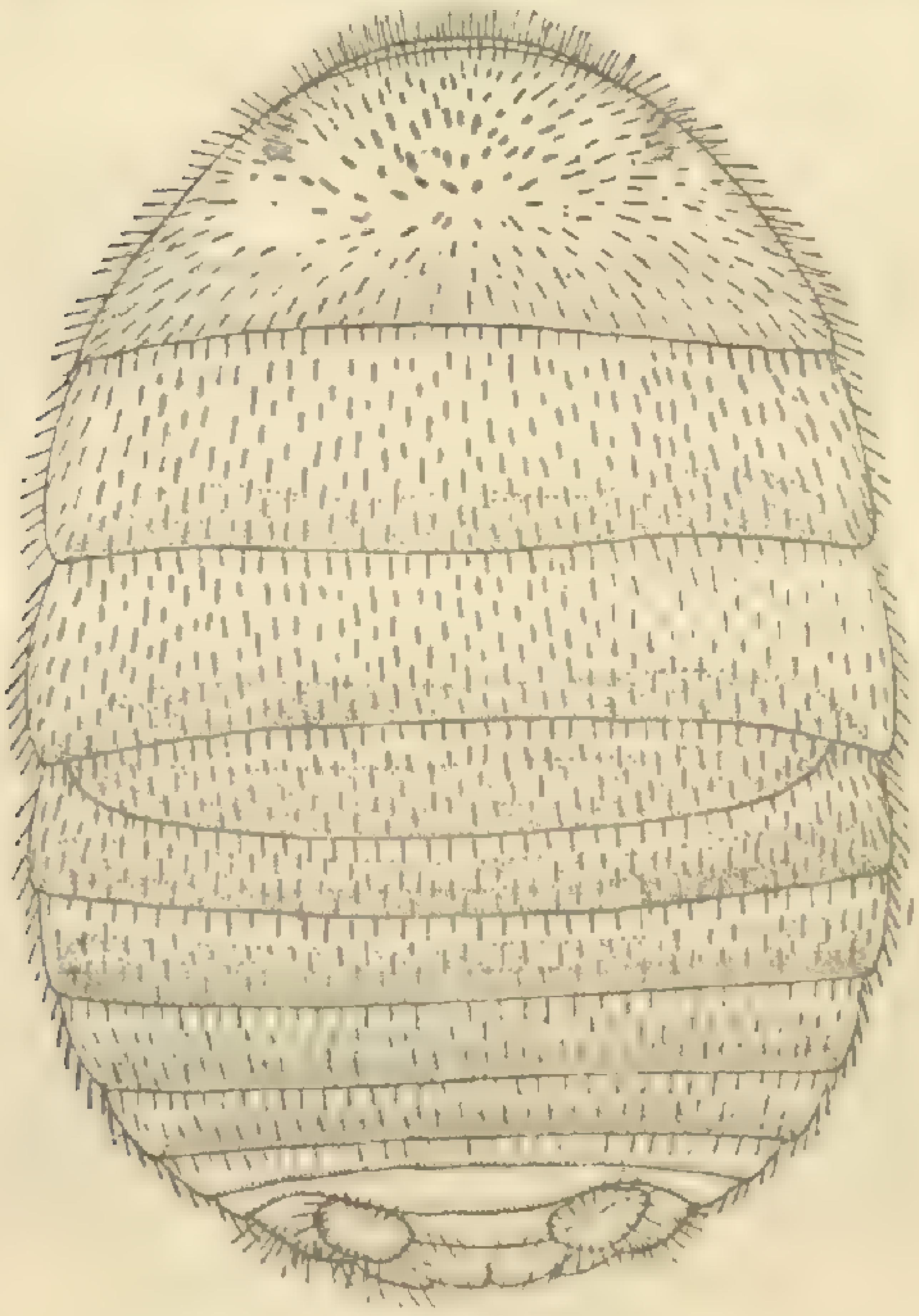

FIG. 4.

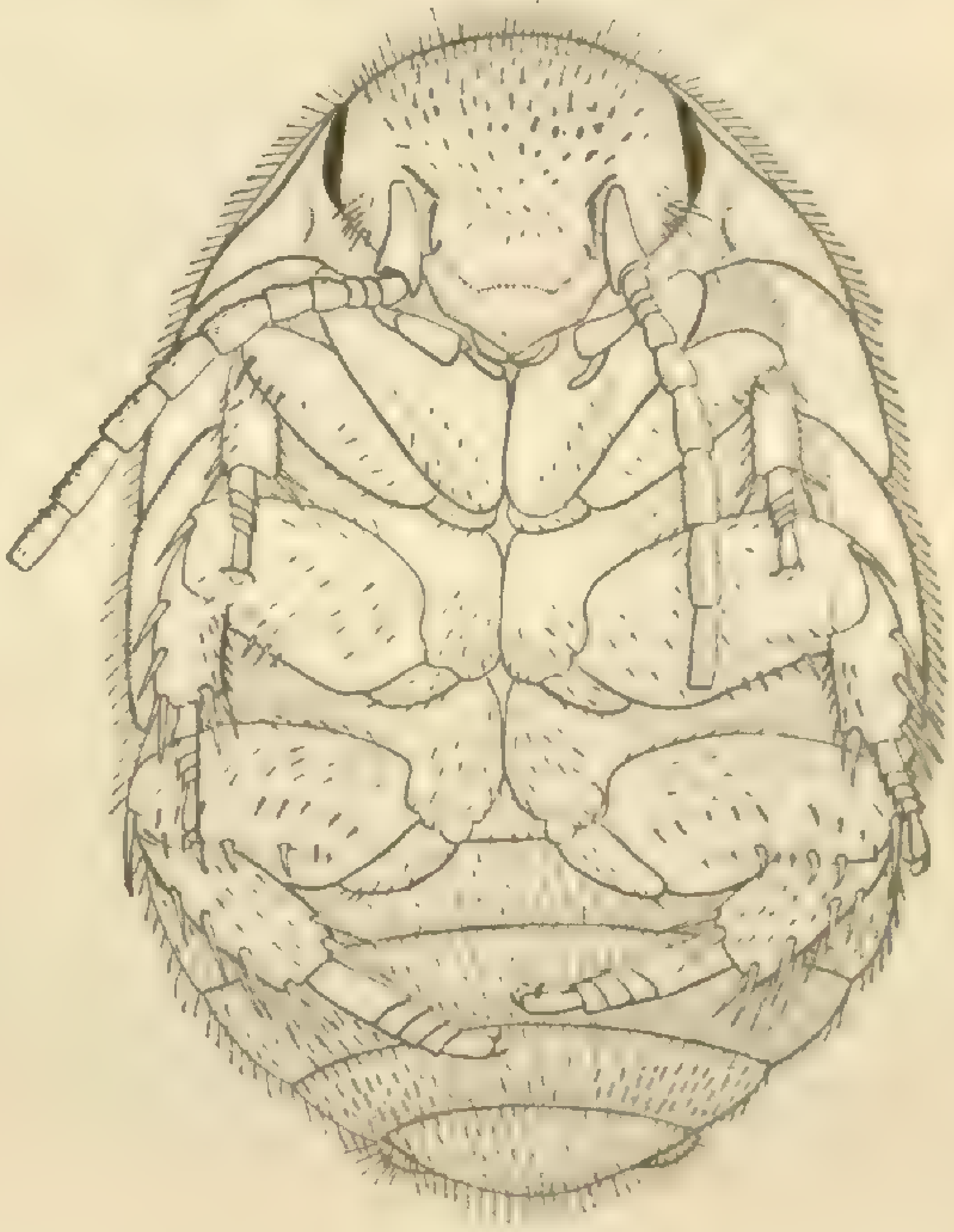

FIG. 5.

FIG. 4. — *Attaphila fungicola* n. sp., female, dorsal aspect.
FIG. 5. — *Attaphila fungicola* n. sp., female, ventral aspect.

in the great Orthopteran order.[2] With Attaphila a genus belonging to a very different family, the Blattidæ, must be added to the long list of insect myrmecophiles. Considering that there is no family of Orthoptera apparently so well fitted to enter into symbiotic relations with ants, it is rather surprising to find that other myrmecophilous Blattidæ have not been discovered, especially in the tropics, where the family is rich in species.

[1] *Études sur les fourmis, les guêpes, et les abeilles.* Note 13, Sur le Lasius mixtus, l'antennophorus Uhlmanni, etc., pp. 1–58, 16 figs. Limoges, 1897.

[2] For an account of the habits of one of the species (*M. nebrascensis* Bruner) the reader may be referred to an article in *Psyche* (1900).

2. While the Orthoptera, as a rule, are large or medium-sized insects, both Myrmecophila and Attaphila are so far below even the average stature of insects of this order that we must conclude either that they have become reduced in size secondarily in adaptation to their present habitat and companionship, or that they were originally diminutive species, and, for that very reason, better able to enter into symbiotic relationship with the ants. The latter alternative seems to be the more probable.

3. The eyes of Attaphila are vestigial in both sexes. This is indicated by their very small size, the greatly reduced number of their facets, and their irregular orbits (Fig. 6). There are scarcely more than seventy ommatidia in either eye, whereas, according to Miall and Denny,[1] there are about eighteen hundred in the eye of the common cockroach (*Periplaneta orientalis*), and some other species have even larger eyes, and therefore, in all probability, a still greater number of ommatidia. The vestigial condition of the eyes in Attaphila is of interest because it shows that the insect has become thoroughly adapted to living in the dark. It is, in fact, a truly cavernicolous form, living in caves constructed by its emmet hosts. The reduction of the eyes has not, however, proceeded so far as in another diminutive cockroach, *Nycticola Simoni*, which is known to inhabit caves in the Philippine Islands.

FIG. 6.—*Attaphila fungicola* n. sp., eye of adult male.

4. Additional evidence of the lifelong confinement of Attaphila to the chambers of the ants' nest is seen in the extremely rudimental condition of the tegmina and wings in the adult male, and the complete absence of these structures in the adult female. There can be no doubt that the specimens figured (Figs. 3–5) were mature, as the testes of the male contained ripe spermatozoa, and the ovaries of the female contained large, elliptical white eggs. The oötheca of this form must be an

[1] *Studies in Comparative Anatomy.* III. The Structure and Life History of the Cockroach, p. 99. London, 1886.

interesting object, if the species actually produces one. My specimens were taken too early in the year, as shown by the great number of immature individuals, so that I am unable to make any statements concerning the breeding habits.

5. It is a singular fact that in every one of my specimens of Attaphila the antennæ are incomplete, so that I cannot ascertain the full number of joints. There seems to be only one explanation of this, *viz.*, that the antennæ have been clipped off by the ants, either by the minims, which are continually trimming the fungus hyphæ, or by the large workers, which cut up the pieces of leaves brought in by the medium-sized workers. It is easy to understand how an insect like a cockroach, living in the midst of thousands of ants which are continually opening and closing their scissor-like mandibles, should be certain sooner or later to have its long antennæ cropped. One wonders how the tarsi of the cockroach escape the same treatment. The human habit of cropping the tails of horses and the ears and tails of dogs may be said to be remotely paralleled by the leaf-cutting ants when they inadvertently clip the antennæ of their household insects. The treatment to which the cockroaches are subjected in the nests of *Atta fervens* — a treatment which they have probably undergone for ages — suggests an interesting problem for those who may still believe in the inheritance of mutilations.

The number of antennal joints that escape the scissors of the ants varies in forty-five specimens, in which they were counted on both sides, from three to eleven. In seventeen of these specimens the number of joints is the same in both antennæ, the variations being: 7–7, 8–8, 9–9, and 10–10. In twenty-one cases the two antennæ differ by only a single joint, the variations being: 7–8, 8–9, 9–10, 10–11. In seven specimens the discrepancy between the two antennæ is greater, being 3–9, 5–7, 5–9, 7–9. Thus in thirty-eight out of forty-five specimens the cropped antennæ are very nearly or quite symmetrical. I am unable to explain this singular condition, which can hardly be a mere coincidence. It is probable that in this symmetrical and cropped form the antennæ of the Attaphila are more like those of the ant, and as they are kept

in constant vibration, they may on that account more readily simulate the "antennal language" of the host insects. This, however, would be the result, not the cause, of the symmetrical clipping.

6. Judging from the stumps which remain, the antennæ of Attaphila differ considerably in structure from those of other Blattidæ known to me. The joints are relatively much larger and longer, and therefore of a more generalized or embryonic type than those seen in the nymphs and adults of other species. Can this somewhat hypertrophied condition be the result of the continual clipping to which these organs are subjected?

7. The structure of its antennæ suggests that a more extended comparison of Attaphila with other Blattidæ may assign it a peculiar, if not unique, taxonomic position. On this matter my limited acquaintance with the insects of this family hardly qualifies me to write.

The following is a more detailed description of the myrmecophile that is the subject of the foregoing general remarks.

ATTAPHILA FUNGICOLA, NOV. GEN. ET NOV. SP.

Male (Fig. 3). — Length, 3–3.5 mm. Color: amber yellow; antennæ, tibiæ, tarsi, pleuræ, tegmina, and overlapping portions of terga and sterna of the thoracic and abdominal segments more brownish. Body about twice as long as broad, glabrous, covered with rather evenly distributed short, yellowish hairs. Head scarcely projecting beyond the anterior margin of the pronotum, so that only its posterior edge is visible when the insect is seen from above. Epicranium and front broad, smooth, without any traces of the λ-shaped suture and fenestræ. Labrum not bilobed, but obtusely pointed, extending a little beyond the acute, tridentate mandibles. Labial palpi scarcely half as robust as the maxillary palpi. Eyes very small, with irregular orbits, occupying the extreme lateral portions of the head and separated by a considerable distance from the antennal foveæ. Antennæ incomplete in all the specimens, both nymphs and adults; first joint rather stout, somewhat longer than the second to fifth joints taken

together ; joints six to eleven of gradually increasing length, but little narrower than the basal joint. Pronotum evenly rounded in front, considerably broader than the meso- and metanota, and as long as both of these regions taken together. There is a brown spot on either side above the eye. Tegmina rhomboidal, without traces of nervures, covering and extending somewhat beyond the meso- and metathoracic segments, and meeting for a short distance in the mid-dorsal line. Wings very small, vestigial, completely covered by the tegmina and exhibiting only very feeble traces of nervures. Abdominal segments short and broad, the first concealed, considerably narrower than the succeeding segments ; terga of seventh and eighth without hairs and lighter in color than the preceding segments ; tergum of ninth segment, forming the lamina supra-analis, subtriangular, not more than one and one-half times as broad as long, rounded behind, and fringed with a few hairs. Cerci very short, not longer than broad, ovoidal, one-jointed, covered with radiating hairs except over an elongate, glabrous area on the upper surface. Subgenital plate small, rounded and smooth, projecting beyond the supra-anal lamina and turned to the left. Above the subgenital plate lies a pointed, spine-like projection (penis ?), which turns to the right side. Stylets apparently absent. Legs short, flattened, the pairs increasing in length from before backwards ; tips of the fore femora far from reaching the pleural edges of the prothorax, those of the hind pair just reaching the lateral edges of the abdomen. All the femora furnished with spines on their lower surfaces. Tibiæ, especially the middle and hind pairs, with robust spines on their extensor edges and at their tips. Tarsi short, flattened, second to fourth joints oblique ; fifth joint provided with a distinct arolium between the claws.

Female (Figs. 4 and 5). — Length 3.25–3.5 mm. Differs from the male in the following characters : Body much broader and more rounded behind ; meso- and metathoracic segments without tegmina or wings, but with broad pleural flaps, so that these segments are slightly wider than the prothorax, though their antero-posterior diameter is only about half that of the large pronotum. Posterior edges of the lamina supra-analis

notched in the middle. Cerci with a very clearly circumscribed, linear white spot on the dorsal surface. Subgenital plate large, nearly as long as broad, evenly rounded behind.

Nymph. — Length, 1.5–3 mm. Resembling the female, except in the smaller size and the distinctly lighter color.

COLEBROOK, CONN., August 20, 1900.

ON THE VARIATION OF THE SHELL OF PECTEN IRRADIANS LAMARCK FROM LONG ISLAND.

C. B. DAVENPORT.

THIS study is concerned with the shells of the prevalent species of scallop, *Pecten irradians*,[1] from Cold Spring Harbor, Cutchogue, Fire Island Beach, and Oak Island Beach, Long Island, state of New York, collected during August and September, 1899.

Pecten (Fig. 1) is a genus of bivalve Mollusca whose nearly circular valves are provided with a number of ridges radiating from the beak at the hinge. The hinge is elongated tangentially, forming a pair of "ears" where the ends of the tangent depart most widely from the circle. The ears of the two valves are very different, as, indeed, are the conditions to which the two valves are subjected in nature. For when Pecten is about three millimeters in diameter it attaches itself, so that it lies in a horizontal fashion, by means of a byssus. It remains attached until it is from ten to thirty millimeters long, after which it lives free. The byssus passes to the exterior between the anterior ear of the right valve and the main body of the shell; consequently, when the right valve is viewed exteriorly, the right-hand ear is deeply notched,[2] while the left-hand ear is not notched at all. In the left valve both

[1] As it is necessary nowadays to recognize that a specific name by itself means very little, a string of synonymy must be appended. Recent names for the "species" or "variety" to which the form-units that I studied belong, are: *Pecten* (*Plagioctenium*) *gibbus*, var. *irradians* (Dall, **'98**, p. 748), and *Chlamys* (*Æquipecten*) *irradians* (Verrill, **'99**, p. 77). Dall recognizes two northern varieties of gibbus: "gibbus var. borealis" of the New England coast, and "gibbus var. irradians" "from New Jersey" south. Neither of his descriptions of these two forms agrees closely with the Cold Spring Harbor form-unit, which might therefore receive a new varietal name were not the futility of this endless naming, alas, too evident.

[2] Fig. 1, top.

ears are unnotched.[1] Since the byssus passes out on the right side, the right side of the young Pecten lies next the substratum, while the left side is broadly exposed to the water above. I was interested to see whether the Pecten ever lies on its left side — a condition which would be comparable in a way

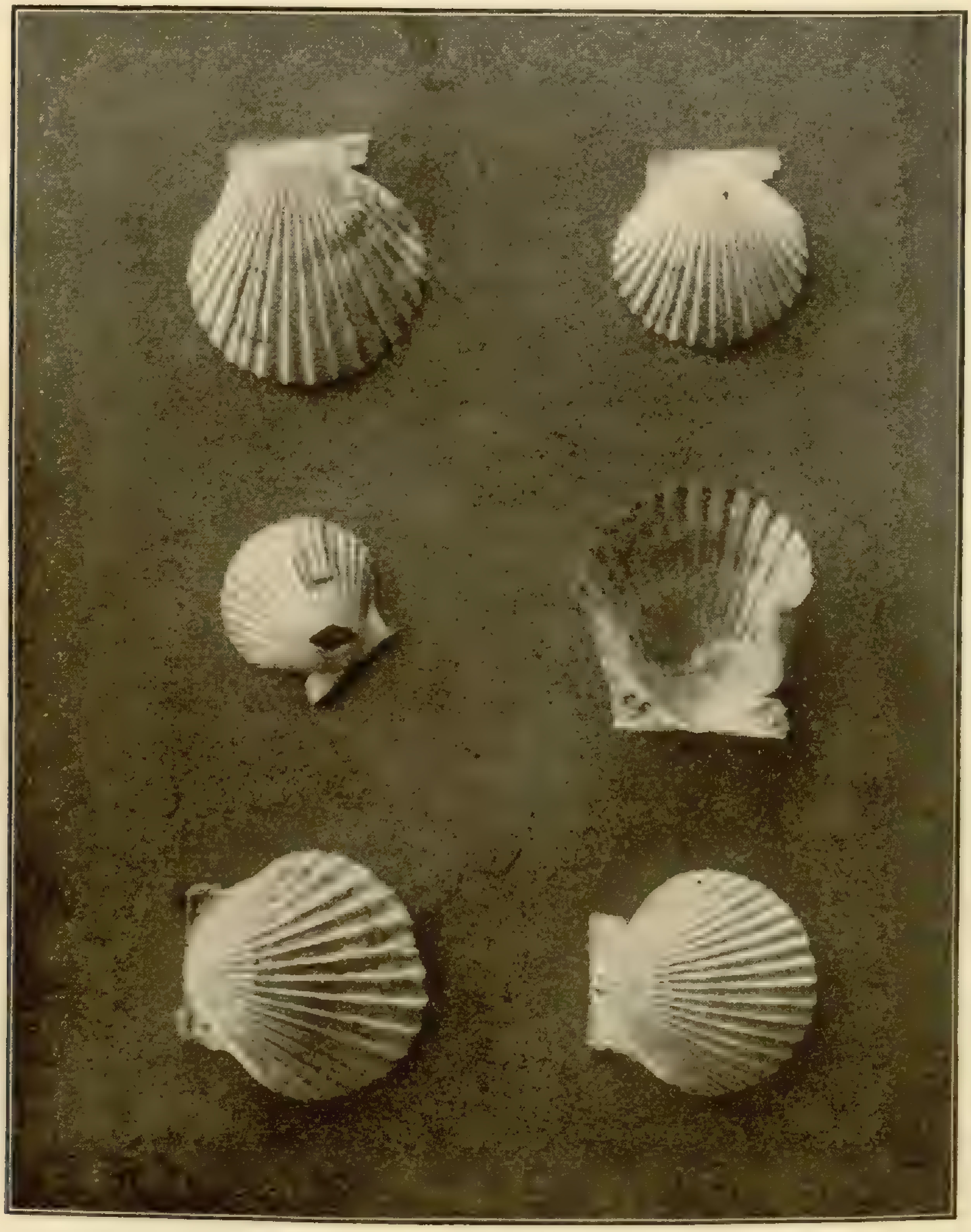

Fig. 1. — Photographs of *Pecten irradians* from Cold Spring Harbor: *a*, *b*, two cases of partial division of a rib; *c*, case of interpolation of a secondary ridge between two primary ones; *e*, *f*, showing an extremely small (14) and extremely large (20) number of rays.

with left-handedness in dextral gastropods. If the abnormal condition ever occurs, it will show itself by the circumstance that the notch will appear on the left side of the valve, viewed exteriorly. Now, although over a thousand notched shells

[1] Fig. 1, bottom, left.

were examined by me, I found no exception to the condition of being notched on the right ear. Jackson ('90) found no exception to the normal condition, and states that Professor Hyatt examined over three hundred specimens of *P. irradians*, all of which lay on the right side. There is, accordingly, a wonderful constancy in the tendency to lie on the right side; and this tendency is characteristic of many related genera, such as Pinna, Spondylus, Plicatula, Hinnites, and Anomia. The constancy in the position of the notch is referable to a constancy in the position of the byssus gland. This is normally laid down in development as a pair of glands, right and left. Apparently only the right gland persists, or else perhaps both glands are united on the right side. Whatever the morphogenetic process which determines the position of the byssus gland, it is a remarkably constant one.

The shell of *P. irradians* exhibits on its outer surface five areas: First, a middle one, characterized by large prominent ridges, alternating with furrows. Since these are made by foldings of the mantle, the outer ridges appear as grooves on the inner surface, and the outer grooves as inner ridges. Second, a pair of "ear" areas characterized by fine linear elevations which do not correspond with marked grooves on the inner face. Third, a pair of triangular areas, lying between the middle areas and the ear areas, and transitional between them. These may be called the "transition" areas. They bear indistinct radial thickenings. These areas are bounded laterally by the ear areas. On the right, or notched, side of the right valve the boundary is distinct; on the left side of the right valve and on both sides of the left valve the lateral limit of the transitional area is determined by the line where the ear begins. But this is not a very precise line. The transitional areas are bounded mesially by the middle area. The limit may be defined as the line where an internal groove corresponding to an external ridge first appears. Since the external ridges on the shell are so often obscure, I early abandoned the attempt to count them. I then noticed that the internal grooves are much more precise than external ridges;

so I counted these grooves to get the laws of variation in the number of radii in Pecten. Such a study is of some importance, because the valves on which the series occur are not typically symmetrical, but show a certain tendency towards being dorsal and ventral. We have here, then, a case among pelecypods resembling that of the flounder among fishes.

The grooves in all the shells examined ran continuously from near the beak to the free margin of the shell. I did not observe any case of bifurcation of a groove, the obliteration of a groove distally, or the introduction of a new groove towards the free margin of the shell. This is the more remarkable because in allied species, such as *P. eboreus* Conrad (see Dall, '98, p. 749), some of the ribs become obsolete toward the margin, and in others, as *P. islandicus*, new grooves are begun at various stages in development of the shell.

The number of grooves corresponds to the number of ridges in the "middle" area. But the number of grooves on the inner face of the shell is not always definite, especially towards the transition area. We here sometimes find a very slight lateral depression passing hinge-ward only one-tenth to one-fifth the whole distance. The rule was adopted to count as grooves only those depressions where the margin of the shell was folded to form a complete U rather than merely an L. A strictly ambiguous or halfway groove at both ends of the series counted for one full groove, but when only one groove was ambiguous, that was omitted from the count. About ten per cent of the shells from Cold Spring Harbor and all from the other two localities were counted by my wife, Gertrude C. Davenport; the rest were counted by myself. We satisfied ourselves of the equivalence of our estimates of doubtful cases by making a series of independent determinations on a number of identical shells, finding that we agreed in our determinations in the case of each individual shell.

The shells from Cold Spring Harbor were picked up on the sand spit, where they had been thrown by waves and shifting sands. They were therefore not pairs, and were not consciously selected. The shells from Fire and Oak Island Beaches were picked up on the beach and were also separate and

often somewhat water-worn and broken by the pounding of the surf which rolls in on that unprotected shore; but no shells were rejected unless so worn or broken as to obscure the grooves. The shells from Cutchogue were very kindly sent me by Mr. Huron Bretsch. Mr. Bretsch writes me that all came from Peconic Bay, near Cutchogue, some from a shell heap left by fishermen, and some picked up on the shore by himself. He says, "I did not pick out the best ones, but took them at random."

Results. — I give in tabular form the observed and per mille distribution of frequencies of the different classes of groove numbers for the two valves from the three localities.

Classes	Right (Lower) Valve						Left (Upper) Valve					
	C. S. H.		Cutchogue		F. I. & O. I.		C. S. H.		Cutchogue		F. I. & O. I.	
	Obs.	P.M.	Obs.	P.M.	Obs.	P.M.	Obs.	P.M.	Obs.	P.M.	Obs.	P.M.
13							1	1.2				
14	2	1.9			1	20	2	2.5	5	32.7	2	95.2
15	15	14.3	33	117.4	6	120	43	53.2	38	248.4	4	190.5
16	108	103.3	95	338.1	15	300	269	333.0	77	503.2	10	476.2
17	515	492.3	127	452.0	24	480	320	396.0	27	176.5	4	190.5
18	308	294.5	22	78.3	4	80	151	186.9	4	26.1	1	47.6
19	90	86.0	4	14.2			22	27.2	2	13.1		
20	7	6.7										
21	1	1.0										
	1046	1000.0	281	1000.0	50	1000	808	1000.0	153	1000.0	21	1000.0

The quantitative study of these seriations gives the following constants calculated from the observed and not the per mille data. Here n is the number of individual shells counted; M is the *mode*, or the prevailing number of rays; A is the average number of rays; σ is the standard deviation or index of variation; c is the coefficient of variation; F is the critical function of Pearson, by which the type of the curve is determined. The numbers following the $\pm$ sign are the probable errors of the determinations. For further information concerning this analysis of frequency distributions, the reader is referred to the works of Duncker in *Roux's Archiv*, 1899, or my *Statistical Methods*, New York, 1899.

	Right (Lower) Valve			Left (Upper) Valve		
	C. S. H.	Cutchogue	F. I. & O. I.	C. S. H.	Cutchogue	F.I.&O.I.
n	1046	281	50	808	153	21
M	17	17	17	17	16	16
A	17.353 ± .018	16.534 ± .034	16.480 ± .084	16.790 ± .022	15.954 ± .105	15.90 ± .14
σ	0.876 ± .013	0.852 ± .024	0.877 ± .060	0.916 ± .015	0.881 ± .075	0.97 ± .10
c	5.049 ± .074	5.15 ± .15	5.32 ± .36	5.457 ± .092	5.52 ± .47	6.11 ± .64
F	− 1.46			− 0.0476		
Type	IV			Type IV or Type V[1]		
Skewness	+ 0.023			+ .0000000058		

[1] $F \times \mu_2^3 = .028; \frac{3\nu_3^2 - 2\nu_1^4}{\nu_4} = .9711.$

Conclusions. — From these numerical results we may draw the following conclusions:

1. The right valve has on the average about half a groove more than the upper valve (more precisely .56+ more). This result is due to the circumstance that the series of ridges and grooves must end either in a ridge or in a groove. Of course it may end in a ridge at one end of the series and a groove at the other; but in the majority of cases there is a high degree of symmetry in the ends of the series. Now I find, in looking over the right and left shells without prejudice, that in the right shells the series tends strongly to end in a groove, so that the last or most lateral ridges of the series (looking at inner surface of shell) are very distinct. In the left valve, on the other hand, there is a more marked tendency for the series to end in a ridge, so that the last grooves are distinct. For in twenty-three right valves I found only three in which the series ended in ridges, whereas twenty ended in grooves; whilst in twenty-nine left valves in fourteen cases the series ended in ridges, and in fifteen cases in grooves.[1] Since the series of the right valve show this prevailing tendency to end in grooves, the excess of grooves on the right valves is fully accounted for. Doubtless if ridges had been counted instead of grooves, the right valve would have averaged one-half a ridge less than the left.

[1] The tendency to end in a groove or a ridge is beautifully shown in *P. operculatus* Linn.

2. The prevailing number of rays in the right valves from all localities is seventeen; in the left valves from Cold Spring Harbor it is seventeen also; but at the east end and the south shore of Long Island it is sixteen. Comparison of the averages shows that the Cold Spring Harbor shells tend to have a comparatively large number of rays on both valves — in the mean 0.8 of a valve more than in the other localities. In the average number of grooves Cold Spring Harbor stands widely separated from the other two localities, which are closely related.

3. Using as an index of variability the standard deviation σ, it appears that the Cold Spring Harbor shells are possibly more variable than those from Cutchogue. However, the difference is less than the probable error, and no stress is to be laid on the fact. The same is true of the apparently greater variation of the South Shore shells. So we may conclude that, despite differences in the mean, the variability of the grooves is constant. This result accords with certain others obtained by *counting integral variates.* Duncker ('**99**, p. 328) says: "While the average values of a character may differ widely in different form-units of the same species, the indices of variability remain fairly constant, not only in the form-units of the same species, but also in those of species belonging to different genera, even to different families. This fact does not seem to me to have been sufficiently regarded hitherto; the explanation of it is, I suppose, the constancy of the physiological capacity of a given organ for reacting to the individual causes of variation . . . with respect to a given character. Some authors, however, seem to assume a more or less constant relation between the height of the average and that of the index of variability of a character." I will not here discuss, as I propose to do elsewhere, the relation between the mean and the index of variation. The matter needs special investigation.

4. The variability of the right or lower valve is in every case less than that of the left or upper valve, and this difference in the case of the Cold Spring Harbor specimens is greater than the probable error. From this fact we may conclude that the right valve is the more conservative, or responds less to

varying environmental conditions. This small variability of the lower valve is in accord with the fact that the young shell of Pecten is larger and better preserved on the right valve than on the left. Again, in *P. squamosus*,[1] in which the scales are becoming obsolete in the adult, they are found at a later stage on the right valve than on the left. In other cases,[2] the grooves of the left valve divide and become ornamented, while the right valve remains simple. Here, then, the index of variability is an index of phylogenetic changeableness.

5. The type of distribution of frequencies was determined only for the shells from Cold Spring Harbor, because they alone were sufficiently numerous for this purpose. The right valve is Type IV, with a rather small skewness however, namely, +0.023. For the left valve the distribution is remarkably near the theoretical normal distribution, the skewness being +.000000058. The skewness will rarely be theoretically zero. Applying Pearson's limits, the distribution may be said to be of the normal type. Applying the prevailing method of interpreting these results, we may say that the Cold Spring Harbor race is, as regards the grooves in the upper valve, very stable; while as regards the grooves in the lower valve it exhibits a slight tendency to the excessive production of a large number of rays, or to the selective annihilation of the small numbers. The excessive production of large numbers may be due to innate or to external causes.

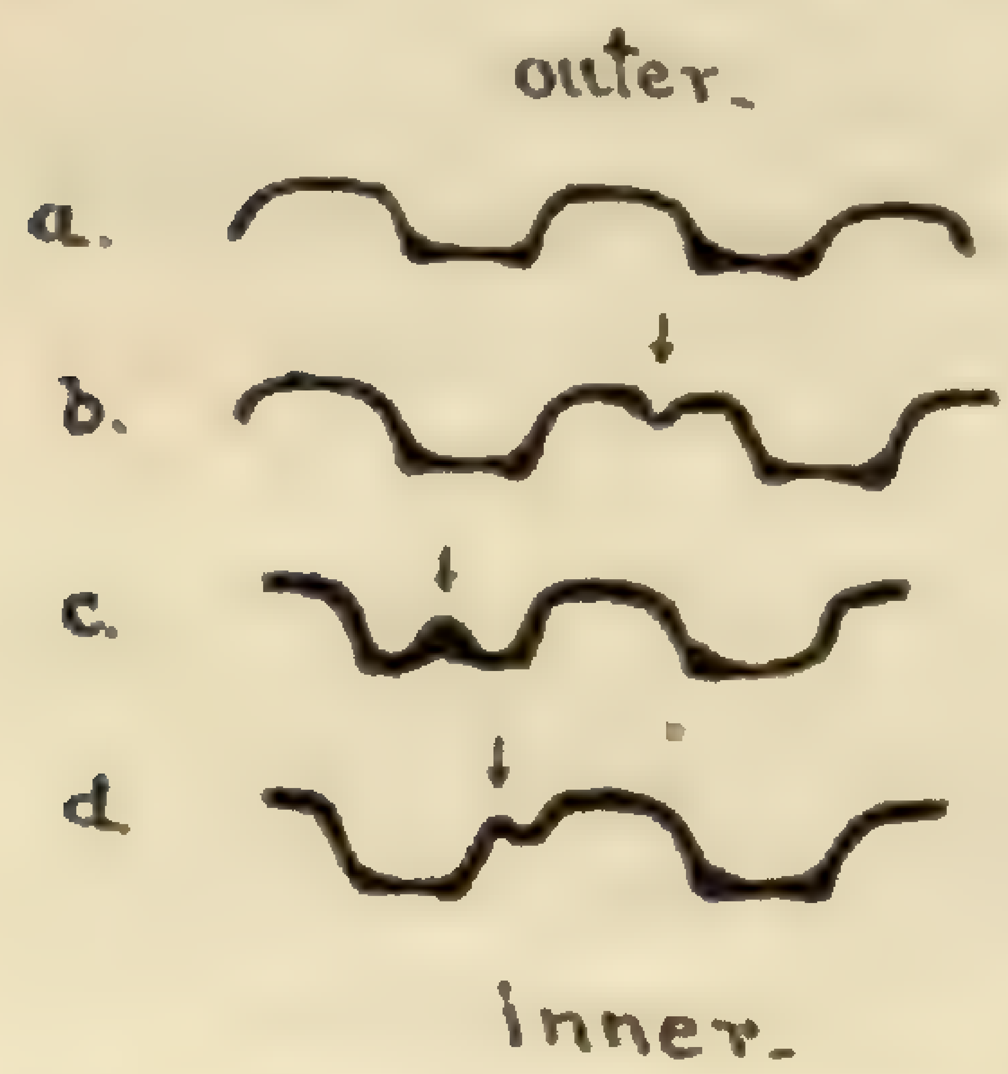

FIG. 2.— Cross-Sections of the shell of *Pecten irradians* (outer surface uppermost); *a*, normal; *b*, a double ridge; *c*, a double groove; *d*, a lateral groove.

Abnormalities of the grooves often occur. All gradations were found between the condition of a broad ridge on the inner face of the shell and the condition of a double ridge, the halves of which were separated by a groove (Figs. 1, *a*, *b*; 2, *b*). In other cases the groove contains a ridge of varying size (Figs. 1, *c*; 2, *c*). Occasionally a small groove

[1] From Mauritius, No. 2412, Field Columbian Museum.

[2] For instance, *Pecten madreporium*, from Singapore, No. 6109, Field Columbian Museum.

lies close by the side of one of normal size (Fig. 2, *d*). All these abnormalities may be regarded as congenital. In addition I have found certain variations, probably due to injury of the mantle. Jackson ('90) remarks that the mantle is subject to injury by fish and thereafter regenerates only imperfectly. He accounts for the incurved edge of the shell which is occasionally found (Fig. 1, *d*) as follows: "When one mantle border is injured, the other repairs the damage which would be caused by local want of shell growth, by curving the shell deposition of the injured side rapidly inwards, thus obviating the deficiency of the injured area. This ingrowth is probably induced by the lack of resisting support on the part of the damaged border."

We have now to consider the question whether the individual variations and the abnormalities which we have studied throw any light on the question of the origin of species in the Pectinidæ. This involves an examination of the genus Pecten.[1]

This genus has been variously subdivided. The subgenus Chlamys (as defined by Dall, '90, p. 695), which includes *P. irradians*, is a fairly well defined subdivision, and our attention may be confined to it. The species all have "ribs," as I shall designate the alternating ridges and furrows, which are true flutings or corrugations affecting both inner and outer surfaces of the shell. If the ribs are absent in any case, they have secondarily become lost. The valves are nearly equally inflated; the ears vary from a nearly equal condition to one of great inequality. The anterior ear of the right valve is typically notched, to let pass the byssus. In judging of the position of *P. irradians* we need to know something of the phylogeny of the subgenus Chlamys. We can infer something, as Jackson ('90) has, on the recapitulation hypothesis, by noting the condition of the shell at different stages of development. The record of these changes remains in the adult shell, and can be studied by examining the beak and adjacent parts. Fossil remains also tell something. The beak

[1] In making this examination I have had the great privilege of examining, with the kind assistance of Dr. S. E. Meek of the Field Columbian Museum, the very fine collection of Pectens possessed by that institution.

of the valves, especially the *right* valve, shows an area without striations; at this stage also the hinge is as long as the greatest diameter of the shell, and there are no sharply marked off "ears." At this stage the shell resembles the Devonian Aviculoids, which are usually regarded from this as well as from paleontological evidence as the ancestors of the Pectinidæ. The genus Pecten began to emerge in the Devonian and Carboniferous. These emerging Pectens, Pterinopecten (Devonian), had a long hinge line, with large, not sharply defined, nearly equal ears, and with a byssal sinus on the right valve. Both the valves seem to have been convex. Jackson ('90, p. 386) says that *Pterinopecten dignatus* Hall and other species bear a close resemblance to the young of *P. irradians*. In Aviculopecten (Devonian), which represents another step towards Pecten, we see the hinge becoming shorter and the two ears well defined; a deep byssal sinus occurs on the right valve in many species. In both Pterinopecten and Aviculopecten the shell is corrugated. These dawning Pectens then had the characters of the subgenus Chlamys, which may consequently be regarded as the most primitive of the subgenera of Pecten. *P. irradians*, therefore, belongs to the most primitive division of the genus Pecten.

Inside the subgenus Chlamys the species show modifications in various directions. There are species in which the posterior ear has become very much smaller relatively than in irradians; *e.g.*, islandicus of our coast, hericeus (= hastatus) of the California coast and Vancouver, and niveus of Great Britain. Associated with this diminution in the posterior ear is the formation of scales in a linear series on the ribs. The scaled condition is secondary, as is clearly shown in niveus, where the younger shell is without scales;[1] the scales are obtained only in the later stages. The inequality of the ears is also derived, for in the primitive condition there was equality of the auricles.[2] This group is therefore more modified than *P. irradians*.

[1] The scales appear earlier on the lower than on the upper shell.

[2] It is interesting that in certain species, *e.g.*, *P. squamosus* of Mauritius, the scales seem to be secondarily disappearing. This species would seem to have originated from an ancestor resembling *P. hericeus*.

A second class of modifications consists in the formation of striations on the ribs. These striations are thickenings of the shell in radial lines. They may in some cases become so pronounced as to form ribs at the periphery of the shell. These striations I regard as secondary, both because they are clearly something added to the simple rays which we have in Pecten, because the young stages of Pecten show no such striations, and because in the young stages of striated shells the striæ are absent. Consequently these striated species are more modified than irradians.

A third class of modifications is that of smooth or nearly smooth shells. Of this condition our *P. magellanicus* (= clintonius) is typical. Although the ancestors of Pecten were smooth-shelled, the magellanicus modification is by no means ancestral, for if, as Verrill (**'99**, p. 78) states, "when about 3–4 mm. in length it develops small, regular, raised ribs over the whole surface of the upper valve and usually at both ends of the lower one," this shell must have been derived from ribbed ancestors. So, too, in *P. glaber* of Smyrna and *P. danicus* of Scotland we have the process of obliteration of ribs going on with the formation, apparently, of a few large secondary crenations.[1] In all cases we start with a ribbed form like irradians.

Let us consider, finally, the relation of irradians to the other species of Chlamys in respect to the number of ribs. The data for such a comparison can be got from an important lot of countings made by Dall (**'98**) and from some determinations of my own made on shells in the collection of the Field Columbian Museum. I give only modes (or, in the absence of sufficient data, the ranges) for the *left* valve. In some cases external ridges are given because these are often alone available and Dall has counted ridges only. In other cases I give internal grooves ; these are exclusively derived from my countings. Since the extreme lateral external ridges usually have no internal grooves, the groove numbers run one or two lower than the ridge numbers.

[1] An insufficient amount of material requires me to put forward this explanation with some reserve.

		Ridges.	Grooves.
P. nodosus,	Southeastern North America . .	7–10	
P. jeffersonius,	Miocene fossils, S. E. North America .		
	var. septenarius	8	
	var. Jeffersonius	10	
	var. edgecombensis	14	
P. latiauratus,	var. monotimeris, California . .		12
P. pallium,	Pacific Islands		13
P. madisonius,	precursor of *P. jeffersonius*, fossil .	15	
P. gibbus,	var. amplicostatus	16	
	var. borealis, recent	17	
	from New England, irradians . .		16
	" South Shore, L. I., irradians .		16
	" Cold Spring Harbor, L. I., irradians		17
	var. irradians, recent	19	
	" " fossil, late Pliocene .	19–22	
	var. dislocatus, fossil, late Pliocene .	18	
	" " recent	20	
P. eboreus,	precursor of *P. gibbus* (= irradians)		
	Miocene and Pliocene	22	
P. operculatus,	British		18
P. hericeus,	Vancouver		19
P. varius,	Naples		24

From this table it appears that *P.* (*gibbus*) *irradians* is intermediate in the number of its ribs between the extremes. The question arises whether in phylogeny the number of rays has been increasing or decreasing to produce *P. irradians*. From the data given and on the assumption that *P. eboreus* is the ancestor of *P. irradians* we have the series:

P. eboreus, Miocene and Pliocene	22 ribs.
P. irradians, late Pliocene	22–19 ribs.
P. irradians, recent	19 ribs.

This seems to indicate that there has been a tendency for the number of ribs slightly to decline. On the other hand, the fossil *P. gibbus*, var. dislocatus (the southern form of irradians), shows an increase from eighteen to twenty ribs in passing from the late Pliocene to the present. Also, the more specialized species, such as varius, twenty-four rays; striatus, fifty-one rays; miniaceus (South Africa), thirty to forty rays; and islandicus (east coast, United States), thirty-five to fifty rays,—

tend to larger numbers than irradians. In many of these cases of species, with a larger number of rays at the periphery, there is an ontogenetic increase. Thus the epionic shell of miniaceus has only sixteen rays, and the left valve of islandicus has only nineteen ridges at 5 mm. from the beak. These species, then, judging from ontogenetic changes, have been derived from species with fewer rays, such as we find in irradians. Finally, Dall ('98, p. 748) concludes in respect to *P. gibbus* (= irradians in part): "Taking all varieties together, the generalization may fairly be made that in the Pliocene the proportion of specimens with less than nineteen ribs is decidedly larger than among recent shells." The apparent contradiction between this statement and the figures which Dall gives for the number of rays in fossil groups suggests that the figures are based on too few individuals to be significant. It may be concluded, consequently, that the condition of about eighteen rays exhibited by *P. irradians* is not far removed from the ancestral condition, and that most of the species with numerous rays have been derived from forms which, like irradians, have fewer than twenty rays.[1]

These facts have a close relation to those of individual variation in our form-unit of *P. irradians*. First, the number of ribs, which is so variable in the individuals of the form-unit studied, is likewise very different in the different species of the genus.

Again, as we have seen, the asymmetry of groove frequencies in *P. irradians* is in the positive sense; that is, there is a tendency to an excess of rays; in other words, there is a tendency to vary in the direction of *P. islandicus;* to go the path that it has trod.

[1] I have paid some attention to the ways in which the increase in rays is brought about in the different species. In islandicus the nineteen rays at the beak increase in the left valve to forty, chiefly by the interpolation of new ridges in the old furrows. Such interpolated ridges start at various stages. In the older shells the increase is also effected by bifurcation of certain of the larger ribs, of which there are about six to eight. In the right valve, on the other hand, the ribs increase chiefly by bifurcation, although interpolations also occur. I have observed the same difference between the left and right valves in other species; namely, *P. alvolineatus* Sby., from Viti (Field Columbian Museum, No. 6111); *P. tigrinus* Müll., from Great Britain (Field Columbian Museum, No. 6118); and *P. madreporarium* Petit, from Singapore (Field Columbian Museum, No. 6109).

The abnormalities of irradians also become significant in comparison with the normal condition in other species. The grooving of an external ridge takes place normally in *P. islandicus*, right valve, as we have seen. The development of a rib by interpolation in a groove is also typical of *P. islandicus*, left valve. The formation of a small rib on the side of a typically large one is found on the left valve of *P. islandicus*, is the regular thing in *P. australis*, from South Australia,[1] and is also common in other species where the number of rays increases with age. How are we to interpret this correspondence between an abnormality and a normal condition in another species? There was a time when we should not have hesitated to put the phenomenon in the category "reversion." But we have so many instances of parallelism between the abnormal of one species and the normal of a second that we should be cautious in attributing them all to reversion. It seems better to recognize that a physiological potentiality which crops out (as an abnormality) in various species becomes fixed as a normal specific character in one of them.

SUMMARY.

The right or lower valve of *P. irradians* has on the average half a groove more than the upper, because the series of alternating ridges and grooves of the right valve has a prevailing tendency to end in grooves. Of three Long Island localities, the most nearly land-surrounded shows Pectens with the greatest number of rays. The right valve is less variable than the left, a result which agrees with the fact that the right valve of Pectens is generally more archaic than the left. The variation is nearly normal in both valves; more so in the left than in the right valve. The skewness is positive, showing a slight tendency towards an excessive production of the many-rayed individuals, or the selective annihilation of those with few rays. This positive skewness is paralleled by the fact that *P. irradians* seems to be developing towards a larger number of rays. The various abnormalities of Pecten are either explained as

[1] Field Columbian Museum, No. 8430.

self-adjustments to accidents or as sports which represent typical conditions in allied species.

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VARIATIONS IN THE CREST OF DAPHNIA HYALINA.

MINNIE MARIE ENTEMAN.

The characteristic tendency of Daphnia to form local varieties is expressed in *D. hyalina* by a variability in the cephalic crest, such that every kind of crest displayed in the genus may be observed in the species, which at the same time remains relatively constant in other distinguishing characters of *D. hyalina*. The object of this paper is a comparison between the American and the European forms, with a more careful inquiry into the conditions for several lakes offering widely different varieties.

My thanks are due to Professor E. A. Birge, of the University of Wisconsin, who furnished me with collections from northern Michigan and Wisconsin, and through whose kindness I had access to the literature on the subject; to Professor C. B. Davenport, of the University of Chicago, for many helpful suggestions in revising the results of my study; and to my brother, Karl E. Enteman, for assistance while collecting from southeastern Wisconsin.

Historical. — *D. hyalina* was first found by Leydig in the depths of the "Schlier See," and was given its name on account of its extremely pellucid character. Following are the chief points in its description as given in Leydig's *Naturgeschichte der Daphniden*, 1860: About as large as *D. longispina*, but somewhat narrowed, and at first sight distinguished from all known species by its extreme transparency; the head prolonged into a long, straight rostrum, without a ventral concavity, and so closely approximated to the thorax that the posterior outline is hidden between the valves of the carapace; macula nigra present; terminal claw smooth, showing under high power of microscope fine cross striations at base; the fornix much higher than in all known forms, the shell delicately

sculptured into rhombs and prolonged posteriorly into a long dorsally directed spine (Fig. 1).

Observers subsequent to Leydig failed to find this species, but described forms which resembled it in all points excepting the form of the crest. The deviations here were sufficiently great to lead to their classification as distinct species. Such were *D. gracilis* Hellich, *D. pellucida* Müller, and *D. galeata* Sars; and not until recent years, when forms transitional between them and *D. hyalina* were found, have these come to be regarded as varieties of *D. hyalina.*

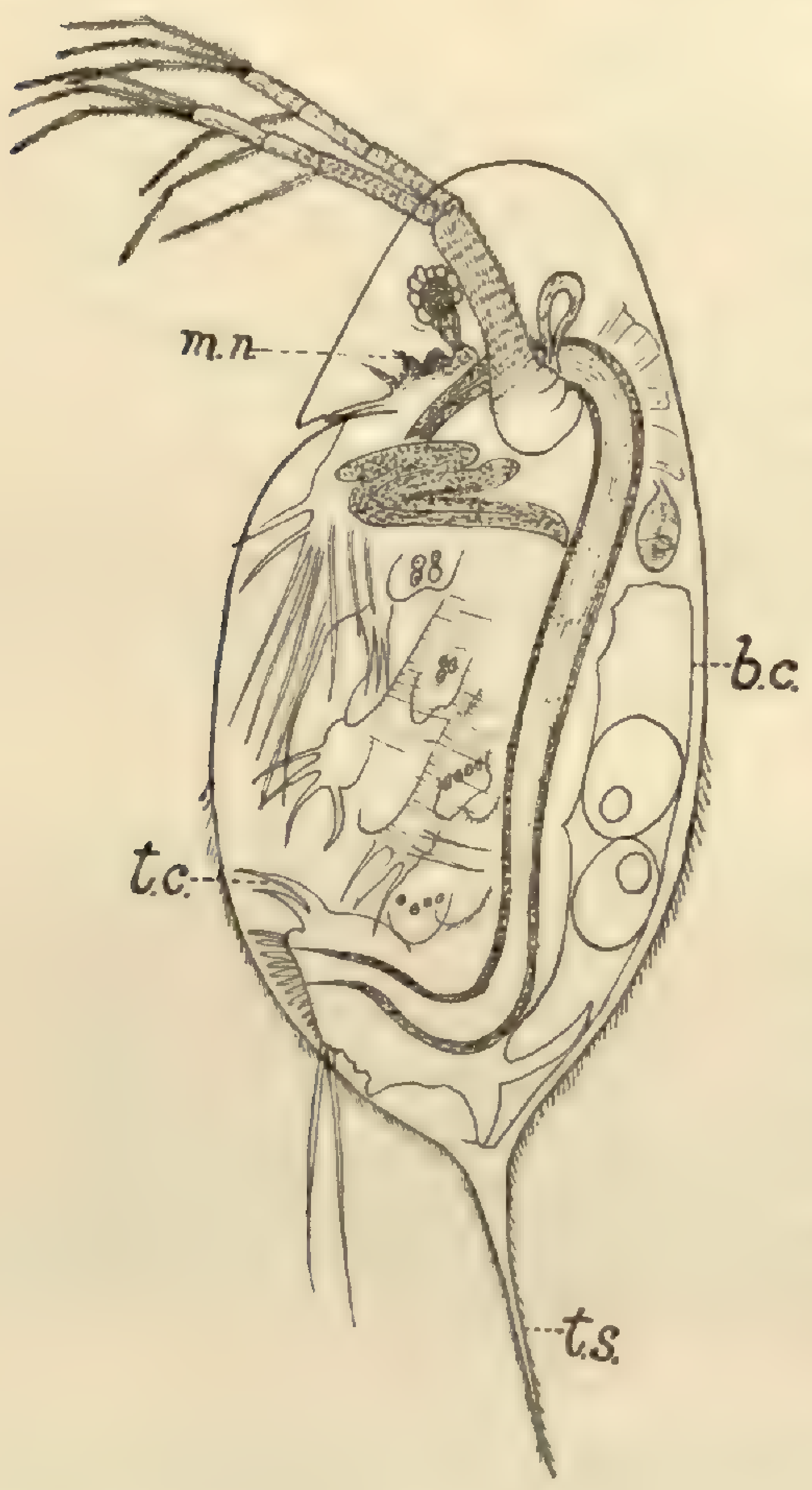

FIG. 1. — *Daphnia hyalina* Leydig; *m.n.*, macula nigra; *b.c.*, brood cavity; *t.c.*, terminal claw; *t.s.*, terminal spine.

Of *D. galeata*, Sars ('63) said: "It is distinguished from all other forms by the very characteristic development of its crest, which projects forward in an acuminate apex, giving the head a certain likeness to a helmet of the olden time. This singular projection undergoes noticeable variations in different localities. Sometimes it takes a direction straight forward, sometimes it is bent downward, and again it is very short, almost disappearing in adult females. In other localities the apex is highly developed, sabre-pointed, and in some even slightly recurved." The writer, however, fails to note a resemblance between any of these varieties and *D. hyalina.* In his résumé of thé characters of *D. pellucida*, Müller ('68) makes mention of a pectinated terminal claw on the telson, which, if it is anything more than the fine striations noticed by Leydig, would serve to separate the two species; but later, in his "Cladoceres des Grand Lacs de la Suisses," he identifies Pellucida with Hyalina, since he found "all transitions between *D. hyalina*

with a low even crest and terminal claw deprived of basal denticles, and *D. pellucida* with a large crest and a terminal claw ornamented at its base by a series of slight denticles." *D. gracilis* Hellich was distinguished from the foregoing mainly by its great height of evenly rounded crest, and was believed to be closely allied to *D. galeata*. Eylmann ('**86**) was the first to recognize the close relationship among the forms hitherto described. He classed them all as varieties of *D. hyalina*. Matile ('**90**) takes the same view. I translate from Eylmann:

"In the course of my work the conviction was more and more forced upon me that all Daphniæ possess a tendency toward the formation of local varieties, and indeed these variations are not limited to one part of the body, but extend to all parts; now it is the shape of the head, now the form of the valves, and again the size and development of the appendages, which give rise to the distinction as a variety. *However, the differences which arise in one habitat are very slight*, and extend to only a few individuals; but if we compare Daphniæ from separate localities, the differences are so striking that a doubt often arises as to whether the specimens are of the same or of different species, and often the question cannot be decided until transition forms are found in other localities which make possible a gradual change from one form to another." He cites *D. hyalina* as the best example of this character, and gives as a reason for these manifold deviations from the type the fact that the species is rigidly confined to lakes, the consequent isolation offering very favorable conditions for the origination of new forms. Richard ('**96**), in his "Revision des Cladoceres," included the above-mentioned forms, together with *D. plitvicensis* Sostaric[1] and *D. rectifrons* Stingelin,[2] in the single species *D. hyalina*, with the remark: "*D. hyalina* est d'ailleurs très variable, comme on le verra plus loin."

The American Representatives of the Species. — These have been but little studied. A brief description of two varieties

[1] Low, rounded crest.

[2] Similar to var. *galeata*.

found in lakes Wingra and Mendota was given in "List of Crustacea Cladocera from Madison, Wis.," by Professor Birge in 1875, while Herrick ('81) has described several forms which plainly belong to this species. Later observation led to the fact that "almost every lake possesses its own variety of *D. hyalina*"; and with this in mind Professor Birge, several years ago, gave me collections from a number of our lakes, and suggested that I study the different forms, their relations to one another and to the various European types. The material was all pelagic and collected from various parts of Michigan and Wisconsin. The lakes differ widely in character, from the small, reed-bordered Lake Wingra, or shallow Winnebago with its sandbars, to lakes like Mendota, of far greater depth, and whose shores slope from precipitous bluffs.

In general, the forms are remarkable for their close resemblance to the varieties of Europe, every variety but one being represented here; while several differ widely from any thus far described for Europe, but correspond in external appearance to the American representatives of widely different European species. Thus, while some European varieties of *D. hyalina* vary in the direction of the Kahlbergiensis, our forms vary to correspond with the American species Retrocurva and Breviceps. The transitions between the different types are sufficiently gradual to connect them with the original *D. hyalina* Leydig, thus seeming to confirm what has heretofore been, in a measure, assumed by other writers, — that the form first discovered is the one from which the others have departed. Following is a diagram (Fig. 2) representing the deviations from an assumed central form found in Lake Wabasis, Michigan, while the table on page 884 gives the principal characters in which the varieties are observed to differ. Each variety is named from the lake where it occurs.

FIG. 2. — Series of forms from the lakes of Wisconsin and Michigan, arranged to show transitions to extreme types of development.

I. Wabasis	VI. Tomahawk	XI. Gogebic
II. Crooked L.	VII. Kawaquesaga	XII. Wingra
III. Mendota	VIII. Reed's	XIII. Vieux Desert
IV. Winnebago	IX. Superior, at Ashland	XIV. Kawaquesaga
V. Twin	X. Ashland	XV. St. Claire.

Name.	Crest.	Rostrum.	Antennæ.	Spine.
Wabasis	Round, low, slightly narrower than carapace	Long	Basal joint curved, barely reaches margin of the head	Long, slightly upturned
Crooked	Little higher than the above-mentioned form	Long		
Mendota	Round, high, more than ½ the length of carapace	Postero-ventral, ending in sharp point	Curved, slender, barely reaching margin	Very long, recurved postero-dorsally
Winnebago	Nearly ⅔ length of carapace and as broad	Short, rounded	Slight, with short basal joint	Middle of lateral aspect, and a little longer than head
Twin	Pointed apex, dorsal to median line of lateral aspect	Rather short	Slight, with short basal joint	
Tomahawk	Apex somewhat more pointed than the foregoing	Rather short	Slight, with short basal joint	
Kawaquesaga, at Minocqua	Apex slightly acuminate	Rather short	Slight, with short basal joint	
Reed's	Antero-dorsal convexity prolonged into blunt apex	Short	Strong basal joint greatly curved	
Superior, near Ashland	Ventral line curved, dorsal straight or curved slightly upward	Extremely short and rounded	Basal joint nearly straight, and strong	
Gogebic	Elongated and strongly recurved	Long and blunt	Short and slight	
Wingra	Triangular, prominent subocular elevation	Short and blunt	Large and strong	Near median line of lateral aspect
Vieux Desert	About ⅓ length of carapace, apex recurved	Long and blunt	Large and strong	
St. Claire	Dorsal and ventral curves marked, apex recurved	Rather long and rounded	Strong	
Kawaquesaga, at Minocqua	Dorsal and ventral curves marked, apex recurved	Rather long and rounded		

Types. — These numerous varieties may be classed under five types, three of which are quite the same as those described for Europe under the names Pellucida, Galeata, and Gracilis, while the other two are peculiar to our lakes. These are the St. Claire form, characterized by slight elongation and triangular shape of the head, and the Gogebic form, with greatly elongated and compressed shell, slender antennæ, and recurved apex of the crest. These two varieties differ most widely from the typical Hyalina, and at first sight appear to be entitled to specific rank. The most striking deviation is toward a form with pointed crest, the apex of which in European forms is ventral and in American varieties is dorsal to the median line of the lateral aspect. Further, the crested variety, as it occurs in Europe, approaches other European species, such as *D. kahlbergiensis*, while our recurved variety is very similar to *D. retrocurva*, the American representative of *D. kahlbergiensis*.

Range of Variation in One Locality. — In two localities only did this earlier material reveal the occurrence of more than one variety. In Lake Mendota two types may be distinguished, one closely resembling *D. gracilis*, the other the extreme round form of Lake Winnebago. Minocqua furnished forms approaching three widely differing types of development: (1) rounded crest, carried out into a sharp point; (2) extremely recurved apex; (3) triangular head with decided prominence over eye. Further examination, however, reveals a much wider range of variation for the single lake.

In the summers of 1896, 1897, and 1898, collections were made from a limited region in southeastern Wisconsin, known as the lake district of Waukesha County, and including about fifty lakes varying in size from the merest pond to those four or five miles in length and thirty meters deep. Thirty-five lakes were visited in all, most of them several times, but only fourteen of these have, up to the present time, yielded material in sufficient abundance for comparative study.

With a single exception these lakes furnish no new types, but in some lakes a single type with slight deviations is present, while others yield what might be considered distinct types, were it not for the occurrence of all imaginable transitions. This

FIG. 3.—Series of forms showing range of variation for three lakes in southeastern Wisconsin.

is best shown by the accompanying series (Fig. 3), obtained in each case from single collections from Pine, Okauchee, and Fowler Lakes. It will be observed that in the two former every transition exists, from the low, evenly rounded to the extremely recurved and elongated crest, and the two series are seen to include all the American forms described, excepting perhaps the extreme of the triangular and the high-rounded types of development.

The amount of these variations was not uniformly great in all the lakes studied, nor for all the seasons in which collections

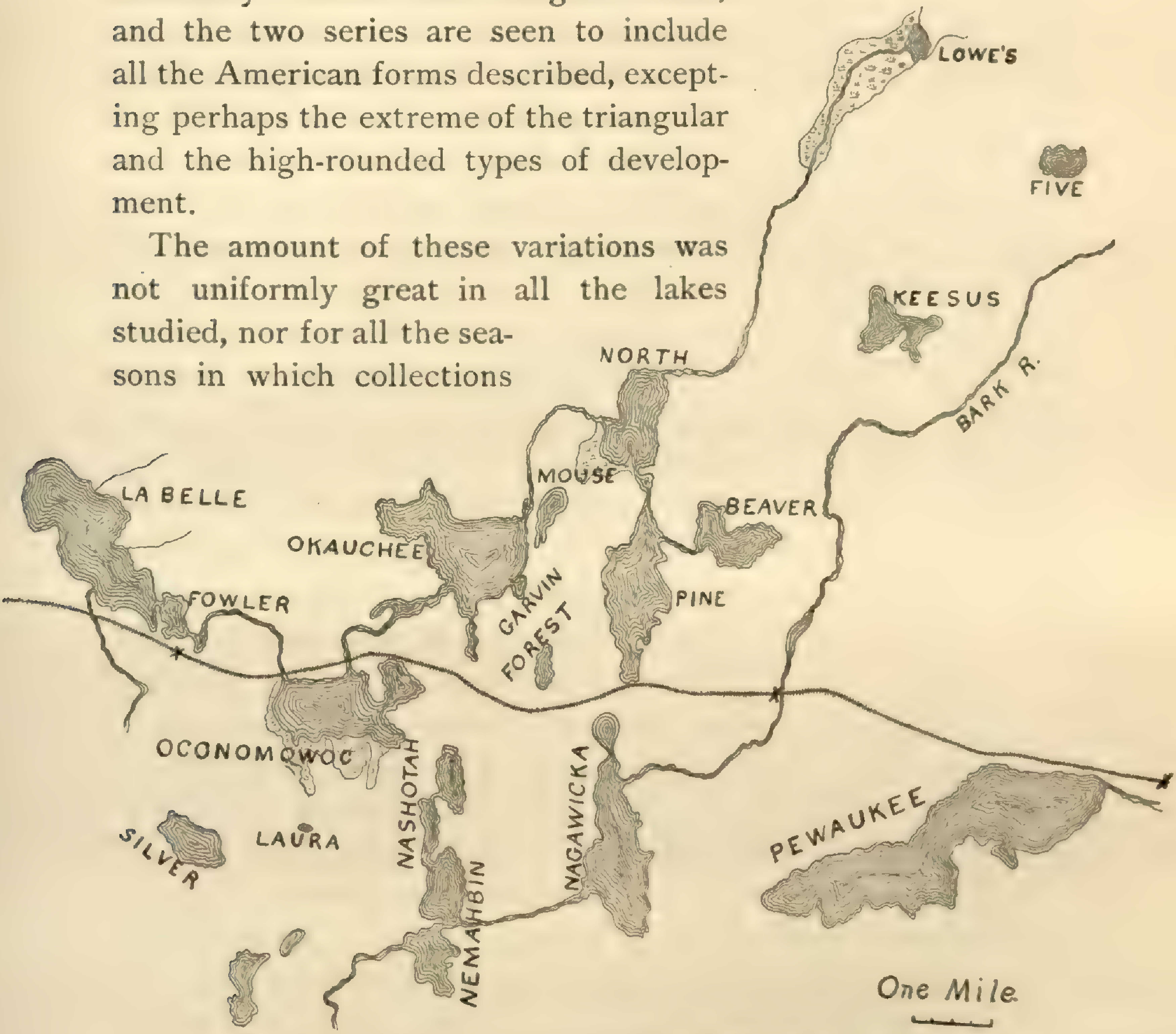

Fig. 4. — Map showing distribution of forms in southeastern Wisconsin. Taken from U. S. Topographical Survey. Lakes Laura and Garvin inserted by writer.

were made. Thus, several collections taken from Beaver, one summer, showed the prevalence of a high-rounded crest with slight tendency to antero-dorsal angulation, while the following summer many crests exhibited a distinctly recurved apex. Lake Garvin, which communicates with Lake Okauchee by means of a channel having an approximate width of fifteen feet and depth of six feet, nevertheless appears to retain a

distinct type of crest. Lake Laura, in the immediate vicinity of Okauchee and Oconomowoc Lakes, and Lowe's Lake, which lies in the same system with these, show a uniform low-crested variety, while Lakes Five and Mouse exhibit the high-rounded type of crest, with marked subocular prominence. The accompanying map (Fig. 4) shows the greater part of the area in which these forms are distributed. The lakes of the Bark River system were very poor in Crustacea and furnished almost no Daphniæ.

Seasonal Variation. — More striking still is the fact that this range of variation is confined to the summer forms. Of course, owing to the difficulty of obtaining material in the winter, no very extended study of the winter forms has been made, but Professor Birge has for years made collections of winter forms from Lake Mendota, and I have his permission to state that they are uniformly low crested, while my own study of the winter forms of Lake Oconomowoc and Okauchee gives identical results. When it is remembered that the summer broods of Daphnia are produced parthenogenetically, the determination of the kind and conditions of variation must have an important bearing on questions of heredity and the origin of specific differences.

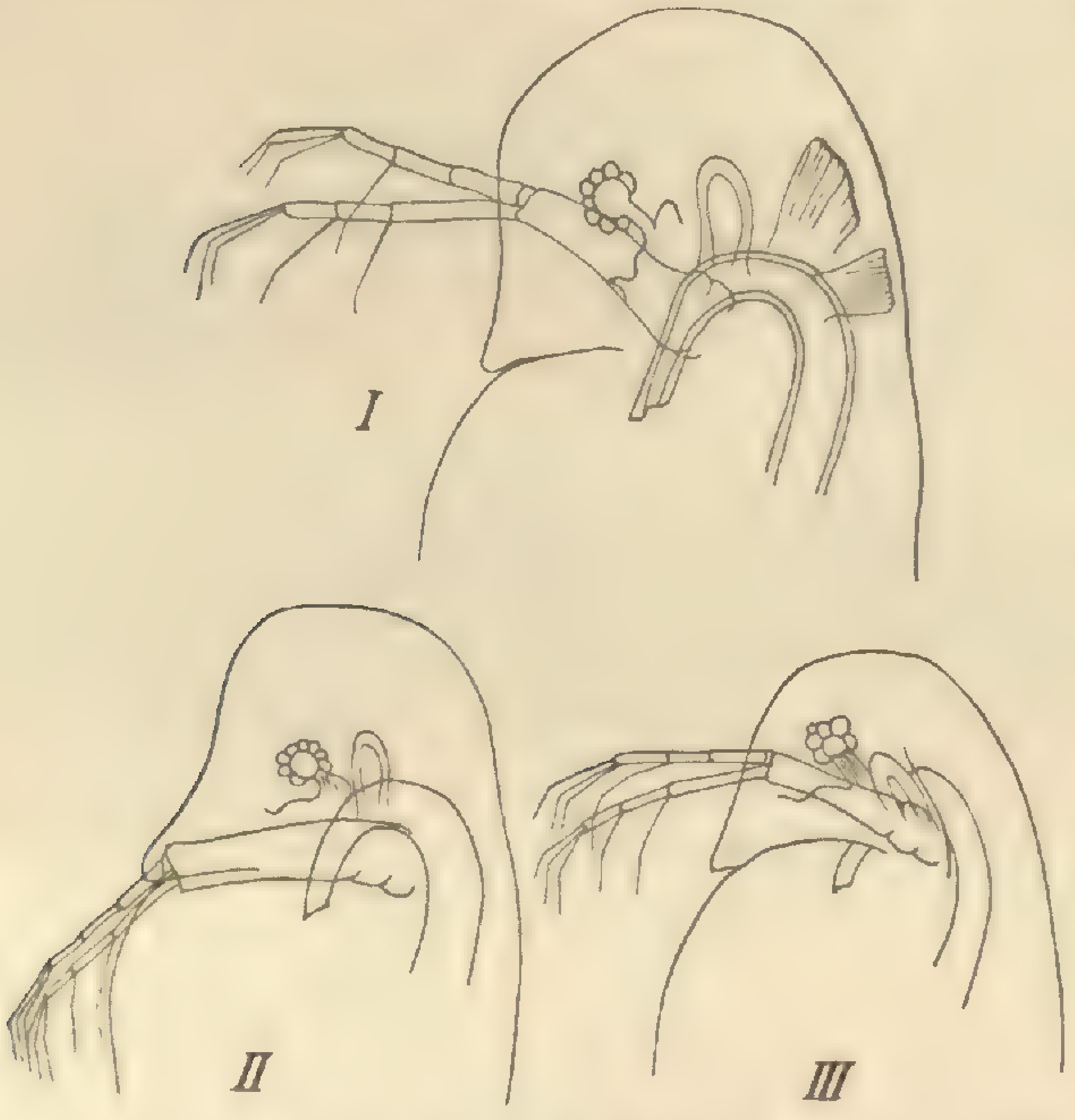

Fig. 5. — I, Lake Five; II, Mouse; III, Lowe's Lake form.

Correlations in Variability. — Although no quantitative study has yet been undertaken, careful comparison shows a direct relation between the length and curvature of the crest and the length and curvature of the terminal spine. The basal joint of the antennæ also varies, in size and strength, with the form and size of the shell. An attempt has also been made to relate the form of the crest with some

character of the environment, such as depth and size of lake, temperature, etc., but thus far the attempt has been unsuccessful. Lakes widely different in character, such as Mendota and Winnebago, possess very similar forms, while some small shallow lakes produce such extremes as those of Lakes Laura and Henrietta (Fig. 6.) Again, the occurrence of a particular variation appears to bear some relation to the forms with which it is called upon to compete. Birge ('**97**), considering the occurrence of *D. hyalina* and *D. retrocurva* in Lake Mendota, states that one declined in numbers according as the other increased, and concludes this to be the result of active competition between the two species. My own much more limited observation indicates a competition in which certain variations are favored to the detriment of others. A more exact study of the quantitative differences, as well as a careful investigation of the environmental influences, will be made before we attempt to show the significance of these variations; but I think the facts as here given may serve to indicate the range of interesting problems offered by a generally accessible but little known form, and thus, perhaps, invite a more extended inquiry into the condition of the species in other localities.

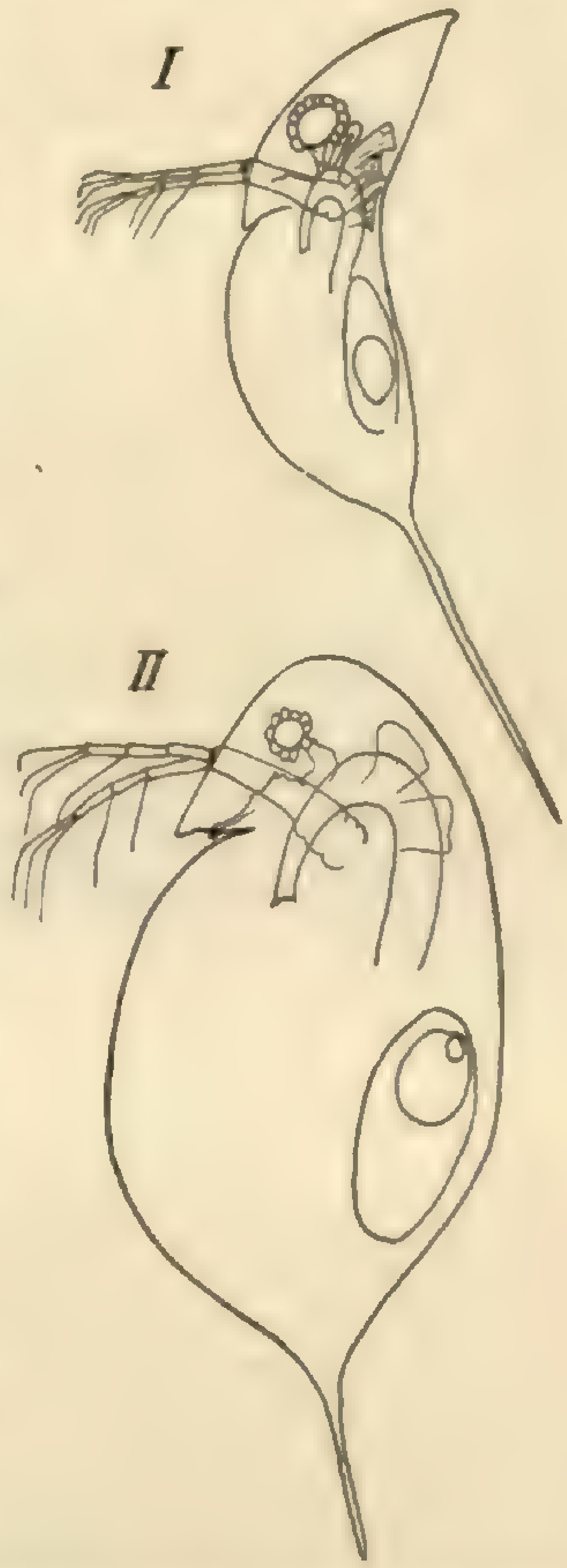

Fig. 6. — I, Form from Lake Henrietta; II, Lake Laura.

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HULL ZOÖLOGICAL LABORATORY,
November 28, 1899.

DOUBLE LOXOSOMÆ.

W. S. NICKERSON.

While investigating the structure of *Loxosoma davenporti* several abnormal specimens came under my observation. These, five in number, are all double monsters, and in all cases the paired individuals are united in the same manner — side to side ; the oral surfaces are turned in the same direction, and the stalks are so united as to have a common foot. Three of

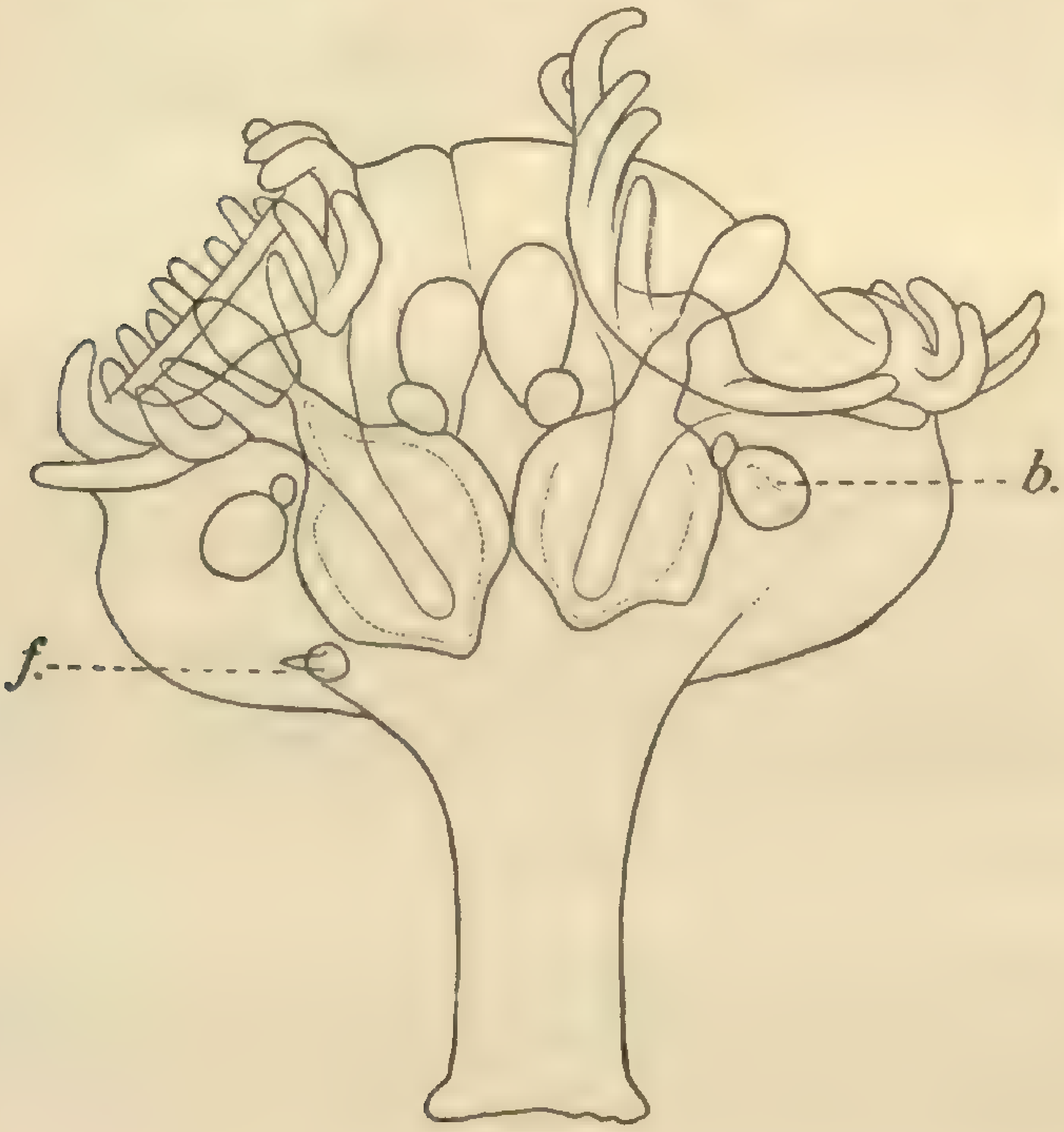

Fig. 1.

Fig. 2.

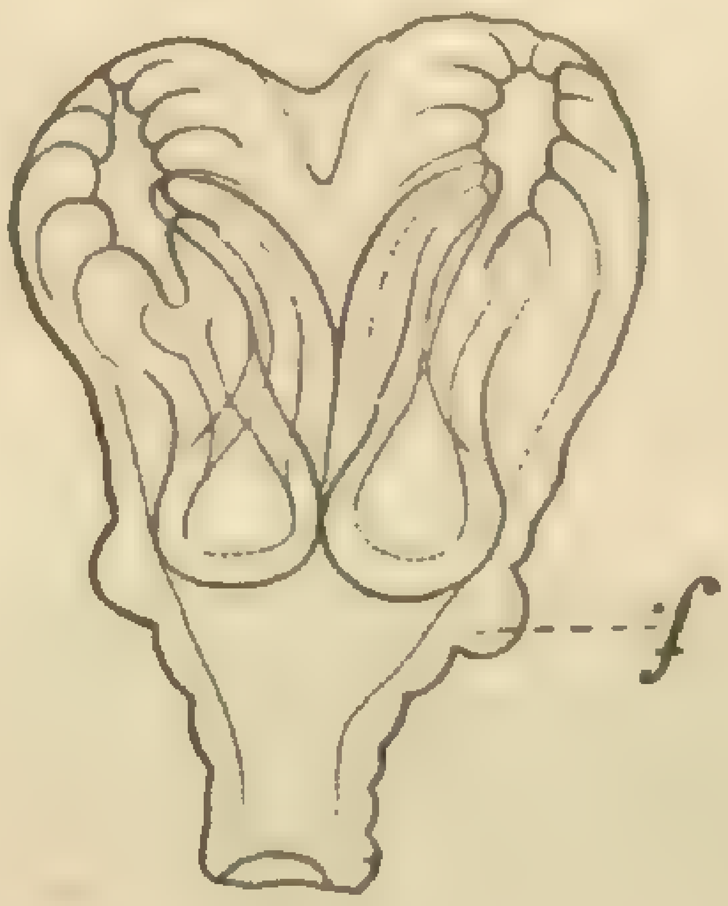

Fig. 3.

Fig. 1. — Anterior aspect. 18 and 19 tentacles. *b.* = bud ; *f.* = flask organ. × 57.
Fig. 2. — Anterior aspect. 16 and 15 tentacles. × 57.
Fig. 3. — Anterior aspect. 11 and 12 tentacles. *f.* = Anlage of flask organ. × 114.

the specimens are fully grown ; the other two are immature, one being a bud still attached to the parent, and the other, though detached when found, was even less developed, and had undoubtedly been separated from the parent by the handling it had undergone in preservation.

These cases represent three different degrees of union between individuals. Three of the cases, one adult (Fig. 1)

and two buds (Figs. 2 and 3), present essentially the same condition. In these a common stalk bears two bodies united side to side, each with its own lophophore, reproductive organs, digestive system, nerve center, and budding zones. In serial sections of the adult (Fig. 1) I have not detected any essential modification of the individual organs. All four of the gonads are ovaries. The two immature buds (Figs. 2 and 3) I have studied only as entire objects, but could discern no abnormalities in the different organs.

A second degree of union is shown by the specimen represented in Fig. 4. Here only the lower parts of the stalks are

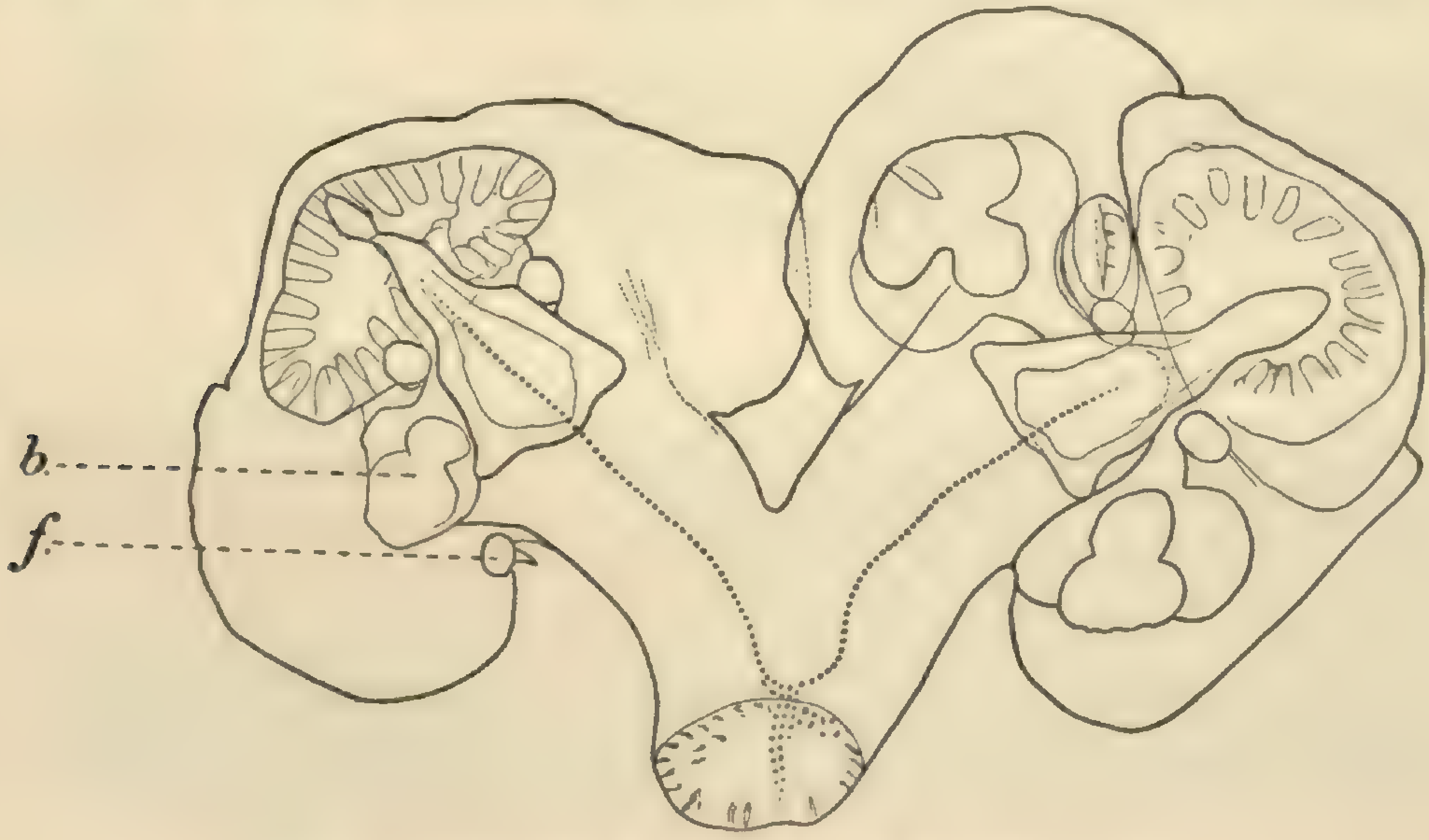

FIG. 4.—Dorsal aspect. *b.* = bud; *f.* = flask organ. × 57.

joined, so that, while the two animals have a common foot, all portions of their bodies above the middle of the stalks are quite separate and normal. The only abnormality observed in individual organs is in the arrangement of the cells of the dorsal row (Fig. 4). Where those of the two individuals come together in the fused stalk near the foot, three rows of the cells instead of two are present for a short distance, and there are slight irregularities in the arrangement of the cells.

A third condition, represented in Fig. 5, shows a greater degree of modification of the individuals and requires a more detailed description. The stalk is simple and in no way different from that of a single individual. From the body arise two lophophores, which are quite normal, and bear respectively

eighteen and twenty tentacles. In the parts located in the body, abnormalities occur in digestive, reproductive, and nervous systems. The position and arrangement of the buds is also peculiar.

The digestive tract consists of a single bilobed stomach, into which lead two gullets, and from which lead two intestines, one gullet and one intestine having the normal relation to each lophophore.

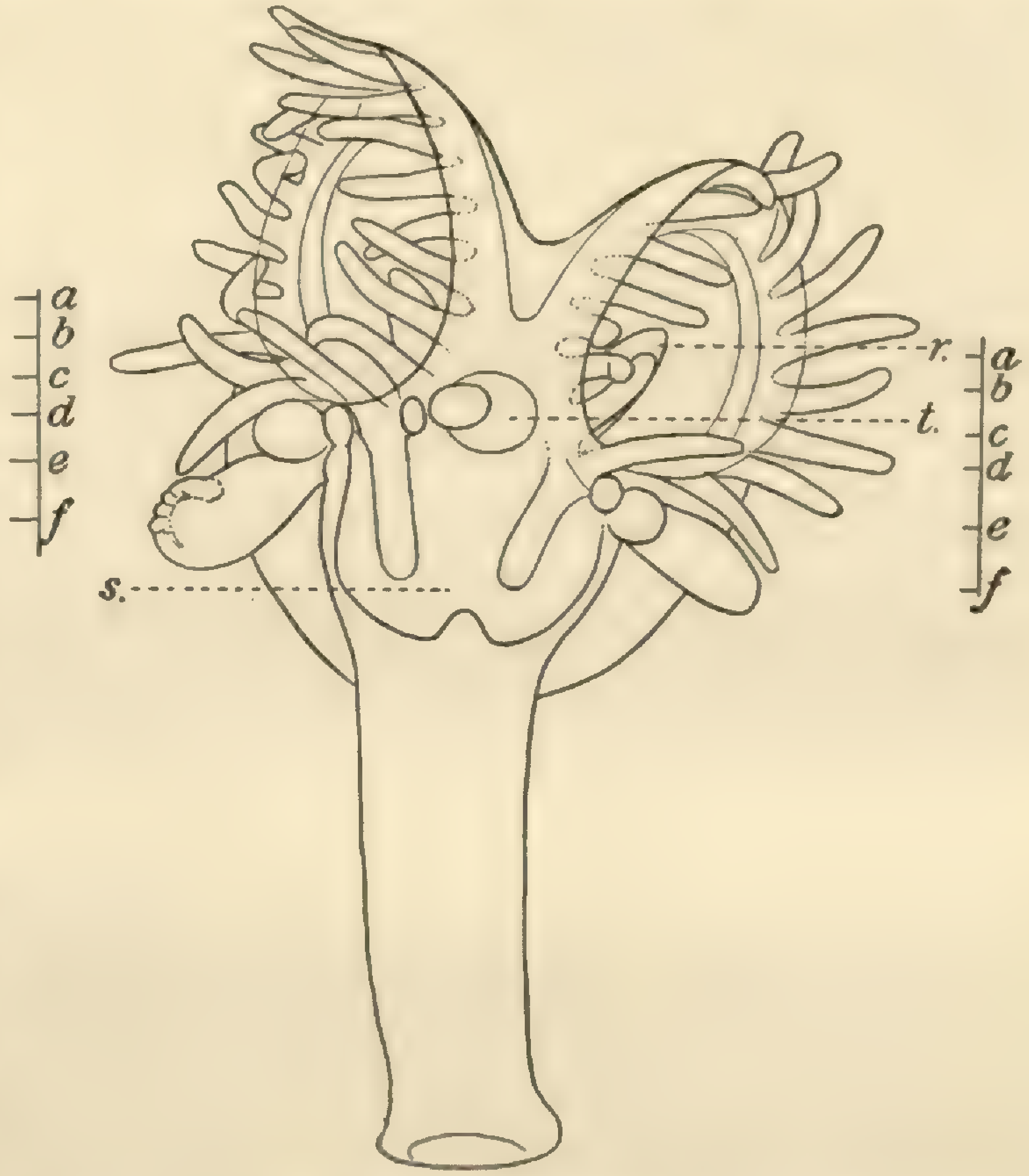

FIG. 5. — Anterior aspect. 20 and 18 tentacles. *r.* = rectum; *s.* = stomach; *t.* = testis. × 57.

The sexual organs consist of three testes, one median above the stomach somewhat larger than the others, and one on the outer side of each œsophagus. A pair of seminal vesicles, one on either side of the median testis, open to the exterior in normal positions with respect to the two lophophores. From each of the lateral testes a duct communicates with the adjacent vesicle. The median testis has an opening into the left-hand seminal vesicle, but I have been unable to detect one to that on the right side, though the two organs lie close together, their cavities separated only by a membrane.

FIG. 6. — Outline of brain made by superposing successive transverse sections. × 250.

The brain has the form shown in Fig. 6, the median portion being somewhat higher than the ends and directly above the

median testis. A nerve bundle passes off from each end as from a normal brain.

There are eight buds arising from three budding zones. The two lateral of these zones bear each three buds, the unpaired zone having but two. These latter have the normal relation to the right-hand œsophagus and lophophore, and are unrelated to those of the other side. I have not succeeded in making out the relations of the excretory organs in this case.

It should perhaps be noted that in each of the adult double monsters (in which the gonads are developed) the paired individuals are of the same sex (Figs. 1 and 4♀, and Fig. 5♂).

None of the buds developed upon any of the double monsters is double or in any way abnormal. The condition therefore appears to be not heritable.

Two hypotheses may be offered in explanation of the facts given. According to one, the conditions found represent three different stages in a process of longitudinal fission. According to the other hypothesis, which I believe to be the correct one, they have resulted from the incomplete separation of two masses of germinal tissue, destined under normal conditions to give rise to two distinct buds. Each individual of the pair represents the resultant of the tendency toward normal development modified by the hampering influence of the adhering mass of tissue. Each double monster is therefore the result of a compromise between the two conflicting bud Anlagen. There seems to be no good ground for comparing the double monsters of Loxosoma and the double embryos normally produced sexually in the phylactolæmatous Bryozoa.

In opposition to the first hypothesis is the fact that the union between the paired young buds (Figs. 2 and 3) is no more intimate than that between the adults shown in Fig. 1, and is less intimate than that between those shown in Fig. 5. If fission were taking place we should expect the older individuals to show the later stages of the process.

Two facts tend to support the second hypothesis: (1) the position of the individuals of the pair with respect to each other is side to side, as would naturally result from the union of adjacent bud Anlagen; (2) in all the cases (four) in which

it has been possible to determine the number of tentacles they have been found unequal on the two lophophores; one of these is therefore in each case more advanced in development than the other, as is always the case with two buds which arise side by side, the degree of difference being, moreover, such as our hypothesis would lead us to expect.

In the specimen represented in Fig. 5 the brain and the stomach correspond in each case to two organs fused. The median testis may likewise owe its larger size to its being the result of fusion of two testes; but whether that be the case or not, its outlet is on the side of the younger individual. The mesial budding zone which has been suppressed or remained undeveloped is that of the younger individual. The latter fact harmonizes well with the theory of fusion, since when two buds come into conflict in their development the younger naturally suffers most. The relations of the median testis, on the other hand, can hardly be considered as lending support to either hypothesis.

Fission seems inherently improbable in so highly organized an animal as Loxosoma, while against the theory of fusion no such objection holds.

University of Minnesota,
July 5, 1900.

REVIEWS OF RECENT LITERATURE.

ZOÖLOGY.

Notes on Recent Fish Literature. — In the *Proceedings of the Zoölogical Society of London* for 1899 (Pt. IV, p. 956, 1900) Mr. G. A. Boulenger records reptiles and fishes collected by John Whitehead in Hainan. The following are described and figured as new: *Corcoperca whiteheadi*, *Gymnostonius lepturus*, *Barilius hainanensis.*

In *Annales and Magazine of Natural History* (Ser. I–V, No. 26, p. 165) Boulenger describes three new species of Siluroid fishes, from the streams of São Paulo, near Santos, Brazil. These are: *Plecostomus heylandi*, *Loricaria latirostris*, and *Loricaria paulina.*

In the *Zoologischer Anzeiger* for June 14, 1900, Hector F. E. Jerngersen, of Copenhagen, gives a study of the urogenital organs of *Polypterus bichir* and *Amia calva.*

In the records of the Expedition Antarctique Belge, M. Louis Dollo, of the museum at Brussels, describes a new deep-sea fish of the family of Chænichthyidæ under the name of *Racovitzia glacialis*, an ally of Gerlachea and Cryodraco, already described by him. Incidentally he calls attention to the fact that the name of the deep-sea genus of *Macruridæ*, *Moseleya*, is preoccupied by Moseleya Quelch, 1884, a genus of corals. The genus of fishes may stand as Dolloa, *nom gen. nov.*, and its typical species as *Dolloa longifilis.* In another paper of similar date Dollo describes as new *Macrurus lecointei*, also from Antarctic depths. In the recent subdivision of this group this species would be placed in the genus Dolloa. It may stand as *Dolloa lecointei.*

In the *Proceedings of the Washington Academy of Sciences* (II, 161), Dr. Charles H. Gilbert records the fishes collected by Arthur W. Greeley as a member of the Branner-Agassiz expedition to Brazil. Eighty-five species were obtained, four of them being described and figured as new. These are: *Upeneus caninus*, from Pernambuco; *Apogon brasilianus*, from Mamanguape Reef; *Sphroides greeleyi*, from Maceio, and *Brannerella brasiliensis* from Maceio. Brannerella belongs to the Clininæ, being near Starksia, differing in the detached

first anal spine and the lack of notch on the spinous dorsal. Dr. Gilbert reduces the list of doubtful species by relegating *Eupomacentrus dienœus* to the synonymy of *E. fuscus*, *Iridio kirschi* to the synonymy of *I. poeyi*, and *Gerres embryx* with *Gerres brasilianus* to the synonymy of *Gerres lineatus*. *Chloroscombrus ectenurus* and *Labrosomus xanti*, species hitherto considered doubtful, are regarded as well established.

In the *Transactions of the Royal Society of Canada* (1899, p. 141), Dr. Philip Cox presents a list of the fishes and Batrachians of Gaspé, Quebec, with notes on their distribution. He finds the species known as *Couesius plumbeus*, *C. dissimilis*, and *C. greeni* very closely related, and suggests their probable identity, at the same time describing two forms of *C. plumbeus*, which he calls varieties. These species will bear further study, the present arrangement being wholly provisional.

In the *Records of the Australian Museum* (1900, p. 193), Mr. Edgar R. Waite makes a number of interesting additions to the fish fauna of Lord Howe Island. These species are described as new: *Amphiprion latezonatus*, *Holacanthus conspicillatus*, *Holacanthus semicinctus*, and *Euchilomycterus quadradicatus*. Euchilomycterus is a new genus of Diodontidæ, having the anterior dermal spines four-rooted. The name Acanthocaulus is suggested as a substitute for Prionurus, preoccupied by Prionurus Ehrenberg, 1829, a genus of spiders. The original date of Prionurus Lacépède is set down as 1830, but its original publication dates from prior to 1828, when it was mentioned by Cuvier. It is therefore earlier than Prionurus Ehrenberg, which is given as 1829. The interest shown by Australian naturalists in their rich fish fauna is most commendable. It is to be hoped that it may crystallize soon in a general manual of Australian ichthyology. I may note that the description of *Gempylus serpens* by Jordan and Evermann, noted by Waite (p. 199), was copied from previous authors, the authors having no specimen in hand.

In the *Records of the Australian Museum* (1900, p. 210), Mr. Edgar R. Waite, of Sydney, records a collection of fishes, mostly from Fremantle, Western Australia, in the Museum of Perth. A new species of Oplegnathus is described under the name of *Hoplegnathus woodwardi*, with an interesting discussion on the difficulties which a man in the field encounters in dealing with scanty literature,

more or less inaccessible and most of it closet made. So far as the reviewer can see, *O. woodwardi* is a valid species. It is well figured by Mr. Waite.

In the *Revista do Museu Paulista*, Dr. Carl H. Eigenmann and Allen A. Norris record (in Portuguese) species of fishes collected by Dr. H. von Ihering about Santos, in the Province of São Paulo. The following are described as new: *Nannoglanis bifasciatus*, *Imparfinis piperatus*, *Gœldiella* (*eques*) (new genus), *Iheringichthys* (*labrosus*), *Bergiella* (*westermanni*), *Perugia* (*agassizii*), *Parodon tortuosus*, *Tetragonopterus multifasciatus*, *Catabasis acuminatus*, *Myletes ticté*. Of the new genera, Imparfinis is an ally of Rhamdiella, and Catabasis of Salminus. The others are based on known species.

Dr. Carl H. Eigenmann sums up his researches on the degeneration of Amblyopsidæ and the reaction of blind-fishes to light in a lecture before the Marine Biological Laboratory at Woods Holl, published by Ginn & Company (1900). He regards the bleaching due to absence of light as an acquired character which is now fully inherited. "It is evident that in Amblyopsis we have the direct effect of the environment on the individual hereditarily established."

In the *Anatomischer Anzeiger* (XVII, p. 313), Professor George H. Parker has a valuable study of the blood vessels of the heart of the headfish or sunfish (*Mola mola*). He finds that, unlike most bony fishes, this species has retained in part the complex structures found in the Elasmobranchs, without the simplification or degradation seen in the ordinary bony fishes. When anatomists realize that not all bony fishes agree even in important characters, they will not so generally confine their studies in fish anatomy to the primitive end of the fish series. There is no more open field in science than that of the structure and development of the different groups of Teleost fishes.

D. S. J.

The "Tierreich" Sporozoa.[1] — The work opens with a summary of abbreviations of technical terms and one for the literary references, together with a systematic index. The taxonomic survey of the various genera and species of the group, which occupies the major portion of the book and follows the general plan employed in the publication as a whole, is complete and better illustrated than some previous numbers. After this comes a list of hosts, which embraces

[1] Labbé, Alphonse. *Sporozoa. Das Tierreich*, 5. Lieferung. Berlin, Friedländer, 1899. xx + 180 pp., 196 figs.

more than six hundred species in every branch of the animal kingdom and which shows clearly by the number of entries — 91 under Vermes, 121 under Hexapoda, 95 under Pisces, and 93 under Aves — what groups are particularly infested by these parasites. An alphabetic index of genera and species completes the work. The fact that, as entered on the last page, the manuscript was closed in December, 1897, while the title-page bears the imprinted date of July, 1899, goes far to explain certain shortcomings in the work, for our knowledge of this group has been particularly widened by some very recent contributions. An additional difficulty in the treatment of these forms is to be seen in the record of 94 known and 29 doubtful genera, embracing 239 certain and 259 doubtful species, as given by the author at the opening of the systematic part.

The system employed by Labbé is as follows:

I. Legion Cytosporidia (spore wanting or without polar capsules).
  1. Order Gregarinida (sporulation not intracellular).
    A. Suborder Cephalina.
      a. Tribe Gymnosporea.
      b. Tribe Angiosporea.
    B. Suborder Acephalina.
  2. Order Coccidiida (sporulation intracellular; no motile free stage in adult form).
    A. Suborder Polyplastina (many archispores).
      a. Tribe P. digenica.
      b. Tribe P. monogenica.
    B. Suborder Oligoplastina (few archispores).
      a. Tribe Tetrasporea.
      b. Tribe Trisporea.
      c. Tribe Disporea.
  3. Order Hæmosporidiida (sporulation intraglobular).
  4. Order Gymnosporidiida (adult amœboid; no cyst).
II. Legion Myxosporidia (spores with polar capsules).
  1. Order Phænocystida (polar capsules distinct).
  2. Order Microsporidiida (capsules invisible in life).

Sporozoa *incertæ sedis:* Sarcosporidia,
Amœbosporidia,
Serumsporidia.

A number of genera, including Amœbidium, Piroplasma, and Babesia, are listed as Sporozoa *incerta*, while Coccidioides and the pseudo-Coccidia are included in an appendix.

It is not to be expected that a group including so many poorly known forms and so many species, genera, and even possible orders,

whose relations are uncertain and concerning whose life history nothing has yet been ascertained, could be satisfactorily monographed at this time. Even the brief interval which has intervened since the completion of the book has furnished positive evidence that certain genera, Eimeria and Pfeifferella, are merely developmental stages in the evolution of other forms, a relation which, by the way, is noted as a possibility in the description of some species in the text. With this the entire tribe of *Polyplastina monogenica* probably disappears, as the species are incorporated into the life history of others in the *P. digenica.* Similarly, in the Oligoplastina the single species of Trisporea is but a chance variation of the usual four-spored condition of that form, and thus another tribe falls out.

The two orders of Hæmosporidiida and Gymnosporidiida are distinguished by the presence of a gregarine stage and of a cyst in the former, and by their absence in the latter. Recent discoveries on the life history of the malarial parasite have shown that this distinction will not hold, and apparently the two orders are much nearer together than most of the families given in the synopsis. In the classification of the Myxosporidia, Labbé has followed Thélohan very closely and has attained a less artificial system than that of Gurley. Under the Sarcosporidia, however, the result is less satisfactory, and in the present ignorance concerning these forms it is not clear that anything has been gained by the suppression of Blanchard's genera, Miescheria and Balbiania, a movement in which the author is not likely to be followed at present, at least.

A considerable number of changes in generic and specific names were necessary where the earlier names were preoccupied; it may be questioned, however, whether changes in spelling, *e.g.*, Plistophora for Pleistophora Gurley, do more than add to the already heavy burden of synonyms. Among familiar names which have been supplanted necessarily may be noted Glugea, antedated by Nosema, Proteosoma by Hæmoproteus, and Drepanidium preoccupied and replaced by Lankesterella. In glancing over the list of genera current among the Sporozoa one cannot help being struck by the dedicational-phobia which has afflicted students of the group!

Among the large number of uncertain genera and species listed, some are capable of being precisionized: thus, of the fifteen doubtful species of Gregarinida briefly described by Leidy, the unpublished drawings for his monograph on the group are still in existence and, it is to be hoped, may be published with satisfactory descriptions. Others of the *sp. inq.* are yet under discussion and will ultimately be

placed; but many of the references are mere rubbish and should be noted as such, to save the labor of future students. Thus, the uncertain genus, Molybdis Pachinger, has been shown by Braun to be in all probability based on eggs of *Distomum turgidum*, and yet no note of this fact appears in the text. If all references to supposed members of the group are to be included, reference should have been made to *Coccidium pylori* Gebhardt, a species founded on a similar confusion. The listing of such forms without explanation entails endless labor on those not familiar with the details of the particular case, and reference should be made under doubtful forms to all such explanations, whether accepted by the monographer or not.

Some instances were noted of opposite conclusions in cases involving very similar conditions. Thus, the author accepts two genera, Hæmoproteus and Halteridium, for the parasites of the avian red-blood corpuscles, but reduces similar forms of man, not only to one genus, but even to varieties of a single species! Some of the differences given to the first-named genera in the text, it should be noted, have never been confirmed since the original observations of Labbé on these forms. Again, he accepts the genus Goussia on the basis of a trivial difference in the form of the sporocyst, but rejects Benedenia as an independent genus, though it differs radically in number of sporozoites produced. Recently discovered differences in life history make the distinctness of this genus unassailable.

Withal, these are minor criticisms; Labbé has traversed nearly untrodden ground. It is not surprising that the results are most satisfactory on best-known territory, *e.g.*, Gregarinida, and weakest in those groups, such as the Coccidiida and Hæmosporidiida, which are not only least known, but which are now the object of careful study at many hands. The work of the author is very complete and is a mine of useful information for workers on this group; remarkably few references are lacking, and only a simple misprint was noted. The figures also are well selected and, for the most part, well reproduced.

HENRY B. WARD.

Faune de France.[1] — Half a century ago this work would have been accepted as very good; to-day it is out of date in classification, in method, and to some extent in illustration. The classification shows little improvement on that of Cuvier. The method is synoptic; in the special synopses the points of comparison are most often

[1] Acloque, A. Faune de France. *Les Poissons, les Reptiles, les Batraciens, les Protochordes.* Paris, Baillière, 1900. Pp. 209, 12mo, illustrated.

well chosen, but they are too few in number; though the data may serve to eliminate all but one of the species compared, they are insufficient to identify that one, with any degree of confidence, in modern definitions of species, varieties, etc., or in view of possible intrusions of outside species. The book was compiled mainly from literature; the illustrations drawn from Moreau and Blanchard are tolerably good, but the few drawn from nature painfully indicate the author's lack of familiarity with his subject. Some of these figures are mere caricatures: for examples, the codfish, *Gadus morrhua; Scomberesox saurus*, *Belone vulgaris*, among others, or the figure of *Spinax niger*, which resembles no known shark. Various figures of dentition show nothing of the basal portions of the teeth. Borrowed illustrations are credited in this way: "*Spinax niger* (E. Moreau)"; this would mean to naturalists generally that E. Moreau was the authority for the specific name, niger. Not all of the species are included.

Notes. — C. M. Fürst (*Anat. Anzeiger*, XVIII, 190–203) has investigated the finer structure of the hair cells in the ear of the salmon. Each hair cell carries a brush of hairs projecting beyond the limits of the cell. The enlarged bases of these hairs give rise to a disk-shaped body just within the cell wall. From this disk a cone-shaped mass extends into the interior of the cell. From the staining qualities of these parts the author concludes that the brush of hairs represents cilia whose basal bodies have united to form the disk-shaped mass, and whose cone organ is represented by the cone-shaped body. In other words, sensory hair cells have the morphological peculiarities of ciliated cells.

The richness of the entomological collections of the Oxford University Museum is well illustrated by Swinhoe's recent volume.[1] Two thousand three hundred species are listed; the Noctuina, Geometrina, and Pyralidina by Swinhoe, the Pterophoridæ and Tineina by Walsingham and Durrant. Many new genera and species are described, and the synonymy and bibliography are given *in extenso*. In method of citation and typographically the pages contributed by Walsingham and Durrant differ from those of Swinhoe; Ægeriadæ, Gelechiadæ, are contrary to the best usage. The work is published in the handsome form characteristic of the Clarendon Press. The eight beautiful plates figure, chiefly, species imperfectly described by Walker.

[1] *Catalogue of Eastern and Australian Lepidoptera Heterocera.* Pt. II. Oxford, 1900. viii, 632 pp., 8 plates.

In the *Proceedings of the Manchester Institute of Arts and Sciences*, Vol. I, 1899 (1900), Mr. E. J. Burnham gives an annotated list of twenty-eight species of Anisoptera taken in the vicinity of Manchester, N. H. To the same publication, and also from the vicinity of Manchester, Miss Susy C. Fogg contributes a list of thirty-five Orthoptera.

In *Novitates Zoologicæ*, Vol. VII, No. 2, August, 1900, Warren describes more than two hundred and forty new species of Drepanulidæ, Thyrididæ, Epiplemidæ, and Geometridæ from South and Central America. More than three-fifths of these new species are described from uniques, and of the others only a few are represented by adequate series.

K. W. Verhoeff (*Zool. Anzeiger*, Bd. XIII, p. 465) reports that railroad traffic in the neighborhood of Sennheim in Alsace has been seriously interfered with by a swarm of myriapods (*Schizophyllum salulosum*) crossing the tracks in a wooded district. The crushed bodies of the animals rendered the rails so slippery as to impede seriously the progress of the trains. The animals were sexually mature males and females, and their migration was caused, the author believes, by over-population, whereby egg-laying was made unfavorable.

A. Dendy (*Zool. Anzeiger*, Bd. XXIII, p. 509) points out that the females of three of the Australian species of Peripatus are provided with well-developed ovipositors, and that two of these species, and possibly the third, lay eggs, a habit unknown in the other species of Onychophora. This justifies, in the author's opinion, the erection of a separate genus for the reception of these three species, and for which the name Oöperipatus is proposed.

Professor Keibel's Normal Tables for the Development of the Vertebrates, of which the first part, published some three years ago, dealt with the pig, have been extended in the recently published second part to the chick (Normentafel zur Entwicklungsgeschichte des Huhnes, von Prof. Dr. F. Keibel und K. Abraham. 1900).

The third part of Oppel's Lehrbuch der vergleichenden mikroscopischen Anatomie der Wirbeltiere has just made its appearance and contains an account of the mouth cavity, liver, and pancreas. In size and number of illustrations this part is somewhat larger than the combined first and second parts, which together deal with the œsophagus, stomach, and intestine.

No. 5 of Vol. IV of the *American Journal of Physiology* contains the following papers: "On the Physiological Action of the Poisonous

Secretion of the Gila Monster (*Heloderma suspectum*)," by J. Van Denburgh and O. B. Wight; "A Study of the Effects of Complete Removal of the Mammary Glands in Relationship to Lactose Formation," by B. Moore and W. H. Parker; and "Brief Contributions to Physiological Chemistry," communicated by L. B. Mendel.

BOTANY.

Briefer Courses in Botany. — In the making of text-books two more or less conflicting tendencies come to the surface — that to reasonable completeness and symmetry of treatment, and that to due brevity. Nearly every general text-book of the past decade or more, if it has met with favor, has appeared shortly in an abridged form. The latest of these abbreviated books are Atkinson's *Lessons*,[1] Barnes's *Outlines*,[2] and Coulter's *Plant Studies*;[3] and each represents virtually a one-term text-book based on the earlier full-year books by the same authors. In the main, the characteristics of the latter pertain to them in their shorter form. Each author approaches his subject from his own point of view, and what has been said in earlier numbers of the *Naturalist* about the fuller books need not be repeated here for the abbreviated editions. A pamphlet of suggestions to teachers, by Dr. Caldwell, accompanies Part II of the fuller edition of Coulter, — *Plant Structures*, — and, while it is not above criticism, is likely to assist even the trained teacher in many small ways. T.

Nicholson's Dictionary of Gardening.[4] — Simultaneously with the appearance of Professor Bailey's *Cyclopedia of American Horticulture*, of which two volumes have already been noticed in the *Naturalist*, comes a supplement to its great predecessor, Nicholson's *Dictionary*, which a competent authority characterized in its day as the best reference book within reach of the gardener and fruit-grower, and a model

[1] Atkinson, G. F. *Lessons in Botany*. New York, Henry Holt & Co., 1900.

[2] Barnes, C. R. *Outlines of Plant Life, with Special Reference to Form and Function*. New York, Henry Holt & Co., 1900.

[3] Coulter, J. M. *Plant Studies*. An Elementary Botany. New York, D. Appleton & Co., 1900.

[4] Nicholson, G. The "1900" Supplement to the *Dictionary of Gardening*, a practical and scientific encyclopædia of horticulture for gardeners and botanists. Hyde Park, Mass., Geo. T. King, 1900. *A* to *F*. 4to, pp. viii + 376, ff., 385, with several colored plates. Price $5.00.

of its kind. Nearly twenty years have elapsed, however, since the work was published, and progress has been both varied and rapid in gardening, so that it is a matter for congratulation that Mr. Nicholson, the well-known curator of the Kew Gardens, has found time to prepare a supplement bringing it up to date. This supplement is to consist of two volumes, of which the first, bearing a preface date of June, 1900, is already in hand. To say that the supplement equals, if it does not surpass, the original volumes is sufficient to indicate that in text and illustrations it is excellent. While for American gardeners Bailey's *Cyclopedia*, being an American work, is likely to be more directly useful, the fact that its scope is limited to this country makes the possession of the Nicholson *Supplement*, as well as the original *Dictionary*, all the more necessary for the larger establishments, which are constantly introducing the better of the plants grown abroad, and for all amateur libraries. T.

James's Practical Agriculture.[1] — The author has embodied in this work the most elementary principles and practical applications of agricultural science in a very pleasing manner. It is especially well adapted as a text-book for beginners in the study of agriculture, and is certainly an impetus for the more general introduction of the subject in the public schools. Agriculture embraces such a broad field, it is impossible to treat elaborately each branch in a text-book of the ordinary size. While these first principles are concisely treated, they are nevertheless clear and accurate, and easily understood by persons not familiar with the study of botany, geology, or other sciences that have to do with agriculture.

The life cycle of a plant is traced from the seed to the mature plant, including both structure and essential conditions of germination and growth. The nature, origin, and improvement of the soil and its relation to the plant are discussed. One part is devoted to various field crops, taking up grasses, legumes, root crops, etc., giving the nature, habit, and treatment of each and the reasons therefor. Another part considers horticulture and its products, including the vegetable garden, orchard, and vineyard. The habits of many of the most common insects and fungous diseases of both field and garden are discussed. Live stock and its product, milk, receive some attention, as well as the history and characteristics of different breeds. H. C. IRISH.

[1] James, Charles C. *Practical Agriculture.* American edition by John Craig. D. Appleton & Co., 1900.

Notes. — Several handbooks of photographic illustrations of the famous Kew Gardens have been placed on the market and form attractive souvenirs of a visit to the charming suburb of London, in which the gardens are situated. The latest of these (E. J. Wallis, *Illustrations of the Royal Botanic Gardens, Kew*, from photographs taken by permission, London, 1900), with half-tone plates 5½ × 6½ in., is prefaced by a laconic note by the Director, Sir W. T. Thiselton-Dyer, who has also written a few words of description of each of the pictures.

Professor Boppe, director of the forestry school of Nancy, with the aid of his associate, M. Jolyet, has brought together in book form the substance of his course of lectures in that institution, illustrating it by a number of instructive, if not always well-done, views, indicating landscapes, plantations, and methods (L. Boppe and A. Jolyet, *Les Forêts; Traité pratique de sylviculture*, 8vo, pp. xi + 488, ff. 95, Paris, Baillière, 1901).

Professor Saunders's extensive experimental tests of woody plants in the British territory to our north are further evidenced by a catalogue of fruit trees under test at Agassiz, British Columbia, published as *Bulletin No. 3*, second series, of the Central Experimental Farm at Ottawa, in which 1217 varieties of apples, 36 of crabs, 557 of pears, 311 of plums, 154 of cherries, 213 of peaches, 53 of apricots, 25 of nectarines, 12 of quinces, 7 of medlars, and 6 of mulberries are included. The recommended varieties are: apples 20, pears 10, plums 10, cherries 11, and peaches 5.

Rev. Arthur C. Waghorne, who, while engaged as a pastor in Newfoundland, has made extensive collections representing the flora of that island during the past decade, died recently in Jamaica, where he went early in the season in the hope of recovering from disease incurred in the performance of his trying duties, which not infrequently involved great hardship and exposure.

Professor Marsh's residence and grounds, bequeathed to Yale University for a botanical garden, are to be made the home of the newly created school of forestry, to the direction of which Professor Toumey has been called. Illustrations of the residence are given in *The Forester* for August.

Current numbers of the *Anales del Instituto Médico Nacional*, of Mexico, contain numerous articles on the native plants of that country which are employed as domestic remedies, etc. In the number

for November last, recently issued, is an especially noteworthy illustrated article on Peyotes, by which name are known certain alkaloid-bearing species of Senecio and Anhalonium.

An index to the new genera, species, and varieties of plants described in the first twenty-five volumes of Engler's *Botanische Jahrbücher* is brought to completion in the number of that journal issued on July 13 of this year. It occupies over ninety double-column pages.

A forest fire about 2000 years ago forms the subject of an interesting article in *The Canadian Record of Science* for July, by G. F. Matthew, who obtains his information from the exploration of the contents of a recently opened bog near St. John.

An illustrated paper on the comparative anatomy of *Chlorophytum elatum* and *Tradescantia virginica*, by Gravis and Donceel, is published in Vol. II of the current series of *Mémoires de la Société royale des Sciences de Liége.*

Some of the unpublished results of the investigation of the tannins by the late Professor Trimble appear in the *American Journal of Pharmacy* for September.

The park and city flora of Detroit, comprising thirteen pteridophytes and eight hundred and forty-eight spermatophytes, is listed by O. A. Farwell in the eleventh *Annual Report* of the commissioners of parks and boulevards of that city.

Mr. Sudworth's account of the White River Plateau and Battlement Mesa forest reserves is reprinted from Vol. XX, Part V, of the *Annual Report* of the United States Geological Survey.

Professor K. C. Davis's papers on the native and cultivated Ranunculaceæ of the United States are continued in Part IV of the current series of *Minnesota Botanical Studies*, the genera Delphinum, Ranunculus, and Thalictrum being passed in review.

The West American Scientist for July contains Part V of Mr. Orcutt's "Review of the Cactaceæ of the United States."

Mr. W. A. Wheeler publishes an ecological paper on the flora of southeastern Minnesota in the most recent number of *Minnesota Botanical Studies.*

A preliminary report by Professor Hume on pecan culture, with figures of the better varieties of nuts, constitutes *Bulletin No. 54* of the Florida Agricultural Experiment Station.

A hybrid of *Quercus phellos* × *Q. rubra*, cultivated in France, is recorded by M. de Vilmorin in the *Bulletin de la Société botanique de France* for November last.

A series of half-tone illustrations of the Californian palm in its native home are published in *The Land of Sunshine* for August and September.

Tsuga canadensis pendula, as cultivated in the grounds of Professor Sargent at Brookline, is illustrated in *Möller's Deutsche Gärtner-Zeitung* of August 18.

A lecture by Dr. Francis Wyatt, on the influence of science in modern beer brewing, is published in the *Journal of the Franklin Institute* for September.

CORRESPONDENCE.

To the Editor of the American Naturalist:

SIR, — Permit me to add a few lines to the review of Garman's Deep-Sea Fishes in the August issue of *The American Naturalist*, for I feel that a work of such importance is deserving of further mention in your pages. Possibly the reviewer in speaking of it as "monumental" and "the most important ichthyological work of the past year" considered such summary praise sufficient. With this I can hardly agree, for the many who are not privileged to see the two magnificent volumes will probably fail to get a just estimate of the true character of this splendid work. That such a monograph on the deep-sea fishes should be dismissed with little more than a long list of species described seems hardly just to the work of the author and to the auspices which made its publication possible. One would not know from the review given in your journal that this report, with its more than four hundred pages of text and one hundred plates, forms Vol. XXIV of the *Memoirs of the Museum of Comparative Zoölogy*, nor that its genuinely monographic treatment of the subject has been worthily aided by the customary admirable presswork and illustrations which characterize the *Memoirs*. Two other extensive works on deep-sea fishes exist: Günther's *Challenger Report* and Goode & Bean's *Oceanic Ichthyology*. It is noteworthy that the latter also is in great part based upon the results of explorations under the supervision of Alexander Agassiz. Mr. Garman's report, while in number of pages and plates intermediate between the other two, is clearly the equal of either in every respect. It certainly should have been noted that among the plates, which are superior to any heretofore published, there are fifteen colored lithographs of deep-sea fishes giving the most perfect illustrations that have yet been produced, and one of the most important of the many contributions of the artist Westergren.

HENRY B. WARD.

UNIVERSITY OF NEBRASKA, LINCOLN,
September 22, 1900.

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(Regular exchanges are not included.)

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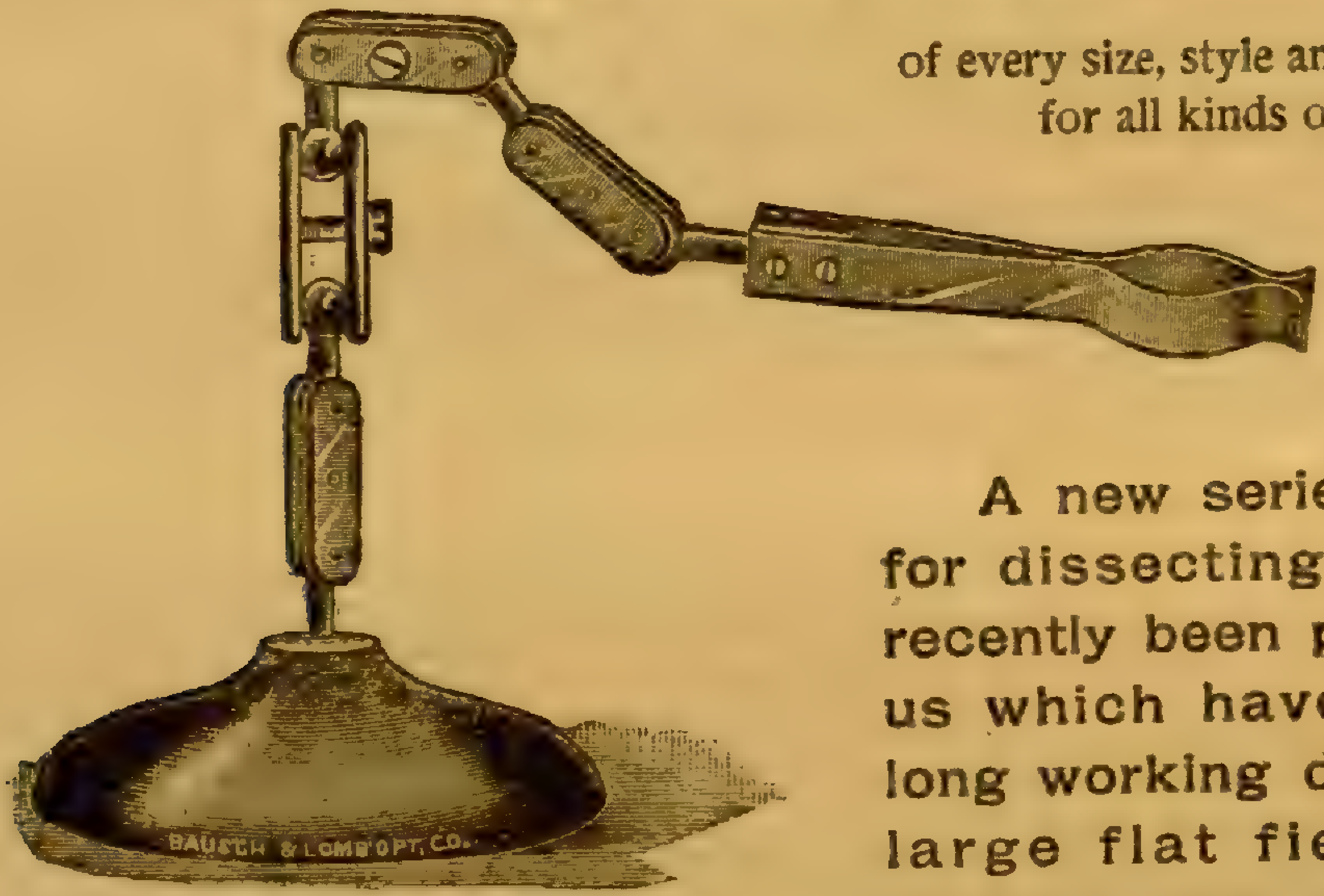

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IN THEIR WIDEST SENSE

CONTENTS

			PAGE
I.	The Study of Mammalian Embryology	Professor C. S. MINOT	913
II.	Origin of the Mammalia, III. Occipital Condyles of Reptilian Tripartite Type	Professor H. F. OSBORN	943
III.	Studies on the Cause of the Accelerating Effect of Heat upon Growth	Professor T. W. GALLOWAY	949
IV.	On the Variation of the Statoblasts of Pectinatella Magnifica from Lake Michigan, at Chicago	Professor C. B. DAVENPORT	959
V.	A Sealing Stone Jar for Zoölogical Laboratories	J. B. JOHNSTON	969
VI.	Reviews of Recent Literature: *Anthropology,* African Masks and Secret Societies, Ancient Crania from the Valley of the Rhone, Notes — *General Biology,* Biology Crystals, Finding Flaws, Recent Work in Electrotaxis — *Zoölogy,* An Introduction to Zoölogy, Merogeny, Skeleton of the Black Bass, Skeleton of Vulpes Macrotis, Notes — *Botany,* Mrs. Dana's Wild Flowers, Our Native Trees, Clements and Cutler's Manual, Notes		971, 976, 979, 986
VII.	Publications Received		990

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THE STUDY OF MAMMALIAN EMBRYOLOGY.[1]

CHARLES SEDGWICK MINOT.

This article is intended to give a preliminary account of a *Text-Book of Embryology*, upon the preparation of which I have been working for a considerable period. The book is intended especially to meet the needs of the student of human anatomy, but it is hoped to render it suitable for use as a general introduction to vertebrate embryology. The distinctive aim of the work will be to direct the beginner in the practical laboratory study of mammalian embryology, guiding him through an intelligent examination of the external form and of the microscopic sections.

The publication of Foster and Balfour's admirable *Elements of Embryology* gave a great impetus to the science, but it is, unfortunately, many years since the last edition of that work appeared (1883). Duval's *Atlas* is at present the most available guide, but is too elaborate and costly to be within the reach of most students. It is a work which ought to be in every laboratory, for it is a fine monument of well-directed learned industry. Both of these works deal with the embryology

[1] Copyright, 1900, by Charles Sedgwick Minot.

of the chick, — the one chiefly, the other exclusively, — and furnish little aid for mammalian embryology. Marshall's *Embryology* is on a more comprehensive plan, but as it scarcely passes beyond the general principles of vertebrate embryology it cannot satisfy the needs of anatomical study. There is in these three works the merit of an adaptation to practical laboratory study, but there are no recent manuals of this type. On the other hand, there is, as all morphologists know, an abundance of recent embryological text-books; but all of them, I think without exception, follow the general pattern established by Kölliker in the first edition of his *Entwickelungsgeschichte* (1861), and offer generalized descriptions of the development of the germ-layers, and then of the various organs. A beginner profits more from a presentation of the subject which clings to the actual preparations which he may make for himself. These considerations have led me to the conviction that an introductory work more or less upon the model of Foster and Balfour would be useful. It is such an "Introduction" which I have undertaken.

The plan adopted is briefly as follows:

First, a study of pig embryos of from 9 to 12 mm. Experience has shown that embryos of these sizes can be obtained in considerable numbers from the pork-packing establishments, such as may be found near most large cities. The anatomy of the pig at this stage is readily understood by the student who knows the general anatomy of the adult. Older embryos are more complicated, and yield such long series of sections that the beginner is apt to be discouraged; younger embryos, owing to their spiral twisting, are exceedingly difficult for students to understand when sectioned.

Second, a study of pig embryos of about 17.0 mm. and of the head of an embryo of 20 to 24 mm., which will suffice to render clear the relation of the early embryonic anatomy to the adult structure.

Third, a study of the chick embryo of 20 to 30 hours to illustrate the character of the germ-layers.

Fourth, a study of the fœtal envelopes, including the placenta in man and perhaps also in the pig and rabbit.

Fifth, a study of the genital elements, impregnation, segmentation, etc.

This scheme is not logical in its order, but it seems to me to follow that psychological order which is natural for beginners in embryology who have already studied anatomy. It is, I believe, often a mistake in introducing a pupil to a new subject to sacrifice the natural, and therefore easy, psychological sequence to the artificial demands of a logical arrangement. I hope, therefore, that the scheme adopted will prove advantageous for laboratory work.

Most stress will be laid upon the young mammalian embryo. Figures have been prepared to show several stages of the pig, all magnified eight diameters. To represent the first stage to be studied, a pig of 10.0 mm. has been chosen (Fig. 1). This figure, as well as the others in this article, are woodcuts after pencil drawings. The drawings were made for me by Mr. E. A. Locke with great care and accuracy. The woodcuts were made by Mr. C. L. Albert Probst, of Braunschweig, Germany, and reproduce the original drawings with remarkable and satisfactory success. The German school of wood engraving uses the black line, while the American school uses the white; so that a German woodcut reproduces microscopical textures better than an American, since in our *stained* sections we rely in our studies chiefly upon the dark or stained parts, and these are indicated by the black-line better than by the white-line engraving. There is the further advantage that the cost in Germany is considerably less. The wood engravings combine softness and delicacy of tone with brilliancy of texture, and thus surpass, it seems to me, very considerably even the best "process" engravings. As the number of good figures of sections of mammalian embryos is very limited, and as there is no series of illustrations of systematically chosen typical sections of typical mammalian embryos, it is hoped that the present series will be useful, not only to students, but also as a convenience to advanced workers. On the other hand, it cannot be claimed that the new pictures represent definite original research, because they are intended primarily for text-book use. I have pleasure in acknowledging very valuable assistance

in the identification of parts rendered by Drs. R. T. Atkinson and F. A. Woods, and by Mr. F. T. Lewis and Mr. J. L. Bremer. Mr. Lewis has made also several dissections of the cephalic nerves, and Mr. Bremer models by Born's method of the brain and pharynx. I hope the results of these researches will be published separately.

I wish also to express my appreciation of the great excellence of the recent text-books of embryology which have appeared in England, France, and Germany, although I venture to point out that they differ in plan from the proposed new book.

A mammalian embryo may be conveniently regarded as having assumed its typical class organization at the time when the limb-buds have just become distinct appendages, as found in pig embryos of 9 to 12 mm. At this stage a mammalian embryo is readily distinguished from that of any other class of vertebrates, and the differentiation of the anlages[1] of all the important organs is accomplished so that these anlages can be identified with certainty and their genetic relations to the adult structures can be clearly grasped by the student. At the same time, although the anatomical differentiation is well advanced, the histological differentiation has made very little progress, so that the stages in question are particularly instructive to beginners. Fig. 1 represents a pig embryo of 10 mm. The student should make a careful and thorough study of the external form, noting the following features. The head, which is very large in comparison with the body, forms as a whole nearly a right angle with the back, so that dorsal outline of the head forms a distinct though rounded angle with that of the back; this angle marks the position of the neck-bend, and corresponds to the junction of the brain with the spinal cord. The neck-bend is one of the most marked and distinctive characteristics of the mammalian embryo, being much less marked in birds and reptiles, and being absent in amphibians and fishes. It is probably closely correlated with the cramping of the ventral cervical region, which leads to the formation of the cervical

[1] Anlage is from the German, and has been adopted as a technical term to designate the first accumulation of formative material recognizable as the commencement of an organ, structure, or part in a developing organism.

sinus (*C.S.*), and to the disappearance of the second to fourth gill-clefts. The neck-bend is so great that the mandibular and nasal regions of the embryo are closely appressed to the cardiac region of the body proper. The cephalic region has a second flexure, the head-bend proper, which marks the site of the mid-brain, and in the figure appears as a rounded angle obliquely above the eye. From the mid-brain one axis, hori-

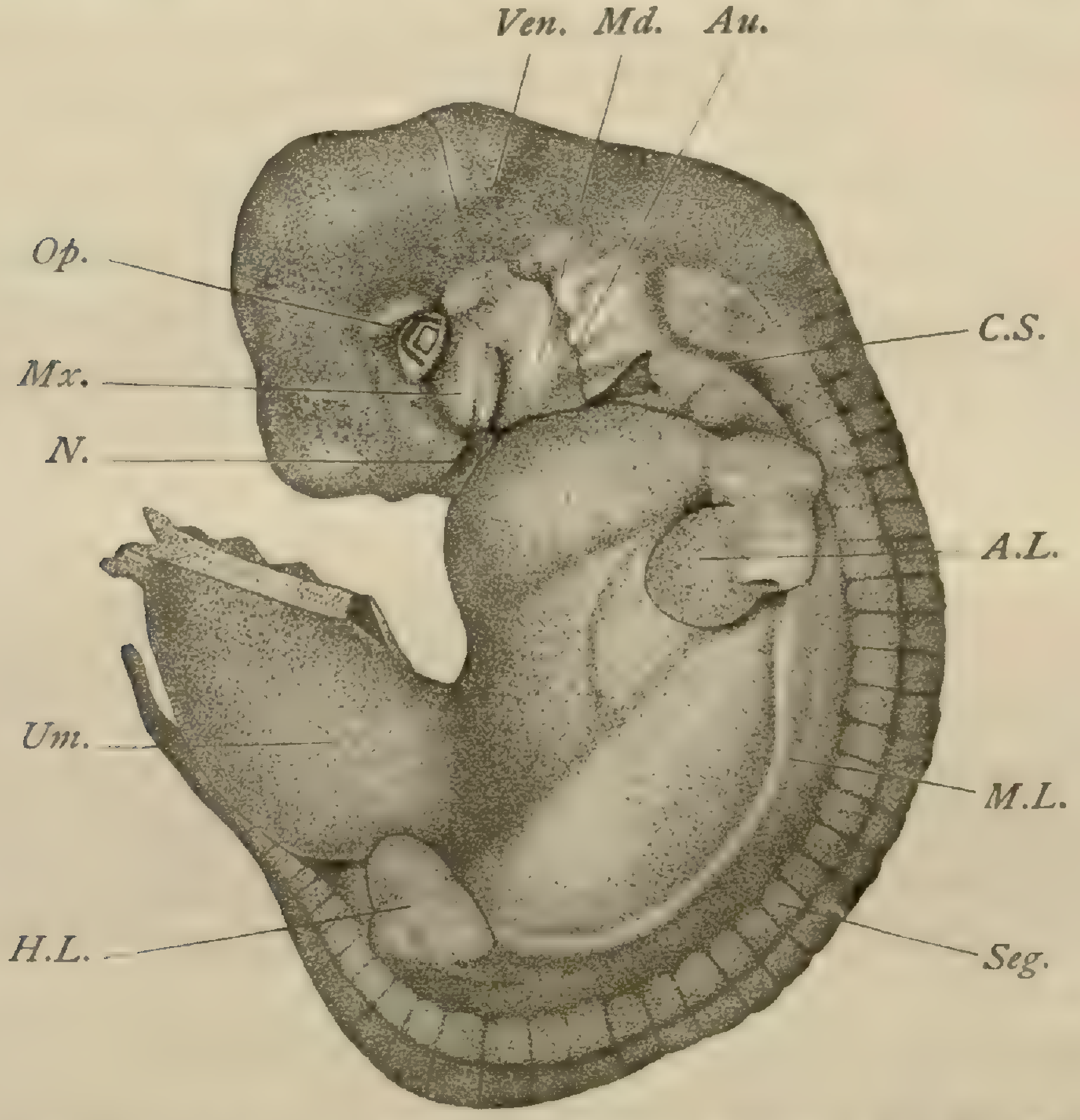


FIG. 1.—Pig embryo of 10 mm. *A.L.*, anterior limb; *Au.*, auditory, or first, gill-cleft; *C.S.*, cervical sinus; *H.L.*, hind limb; *Md.*, mandibular process; *M.L.*, milk-line; *Mx.*, maxillary process; *N.*, nasal pit; *Op.*, eye; *Seg.*, muscular segment; *Um.*, umbilical cord; *Ven.*, floor of fourth ventricle (medulla oblongata). × 8 diams.

zontal in the figure, extends backward through the region of the fourth ventricle, or hind-brain (*Ven.*), to the neck-bend, while the other axis extends vertically downwards to the region of the fore-brain, which is marked by a rounded protuberance in the outline of the head. The dorsal outline of the body proper forms a long sweeping curve, ending in the tail; this dorsal curvature is another characteristic of the amniote embryo, the back in the embryo of fish-like forms being

relatively straight. It is thus brought about that the dorsal side of the embryo is two or three times as long as the ventral. From the ventral side springs the large umbilical cord, the connection of which with the body occupies practically the entire length of the ventral median line of the abdominal region proper. Above the umbilical cord the protuberant outline of the cardiac region passes below the nasal (*N.*) and mandibular (*Md.*) regions toward the cervical sinus (*C.S.*). The long tapering tail extends near the umbilical cord.

The surface modeling of the embryo offers important features. Beginning with the head, we observe first the shallow depression, constituting the nasal pit (*N.*). The eye (*Op.*) is entirely without lids; the lens appears in the center and is surrounded by the outlines of the optic vesicle. The small size of the eye is a characteristic of the mammalian embryo; by which it differs from all sauropsidan forms, but in certain other mammals the embryonic eye is slightly larger than in the pig. Below the eye is the maxillary process (*Mx.*), which is destined to form the greater part of the upper jaw; the anterior boundary of the maxillary process is marked by a shallow depression, the lachrymal groove, which runs from the angle of the eye (*Op.*) to the nasal pit (*N.*). The mandibular process (*Md.*), out of which the lower jaw is developed, is bounded in front by a groove separating it from the maxillary process, and behind by a second groove (*Au.*), the anlage of the future meatus auditorius externus. This groove marks the boundary between the mandibular process and the first or hyoid branchial arch, and is itself the ectodermal member of the first gill-cleft. The fourth ventricle (*Ven.*) or cavity of the hind-brain, having very thin walls for its roof, can be readily distinguished. The thickened floor of the fourth ventricle is the anlage of the medulla oblongata. The cervical sinus (*C.S.*) is an area of invagination, presenting at this stage a triangular outline; within the sinus are found the external or ectodermal terminations of the second and third gill-clefts. The territory of the mandibular process and cervical sinus corresponds to the pharyngeal region. It is the site of some of the most

important, interesting, and complicated developments by which the embryonic is changed into the adult anatomy.

The body of the embryo shows the position and number of the segments (*Seg.*) by the external modeling. Both limbs are well advanced, the anterior (*A.L.*) more so than the posterior. From the base of the front to the base of the hind limb extends the milk-line (*M.L.*), curving so as to be nearly parallel to the dorsal outline of the body. Along this line the mammary glands are ultimately developed. Extending across the body are several shadowy lines, shimmering through the translucent body-walls. One marks the position of the embryonic diaphragm; it extends from the upper edge of the anterior limb obliquely downwards towards the edge of the umbilical cord. Another, which extends in a nearly straight line from limb to limb, marks the ventral edge of the large Wolffian body or mesonephros, the dorsal limit of which is approximately indicated by the milk-line (*M.L.*). The outlines of the smaller left dorsal lobe of the liver are distinct, and mark out a pointed area immediately below the fore limb (*A.L.*).

Of the remaining figures, 2 to 7 represent six transverse sections through a pig embryo of 12.0 mm. But the position of the sections can be easily followed with the aid of Fig. 1, which represents a slightly younger embryo. The plane of the sections would be indicated by a nearly horizontal line across Fig. 1. The sections are ten microns in thickness, and are 966 in number, not 1200, as the student might expect. The discrepancy is due to the shrinkage of the embryo when imbedded in paraffine. The shrinkage is always very great, and in the case of embryos causes a loss of almost 20 per cent in the length; but as it seems to take place uniformly throughout the embryo, it causes no distortion, so that the embryo in paraffine is an exact though greatly reduced copy — so to speak — of the living embryo. It should be remembered that no correct measurements of the size of organs or cells can be obtained from sections made by the paraffine method. This limitation upon the use of sections is too often forgotten.

The six transverse sections chosen were selected to show the most important points in the structure of the embryo, as

far as the upper part of the abdomen. The organs of the pelvic end of the abdomen and the character of the muscles can be more advantageously studied in other series and stages.

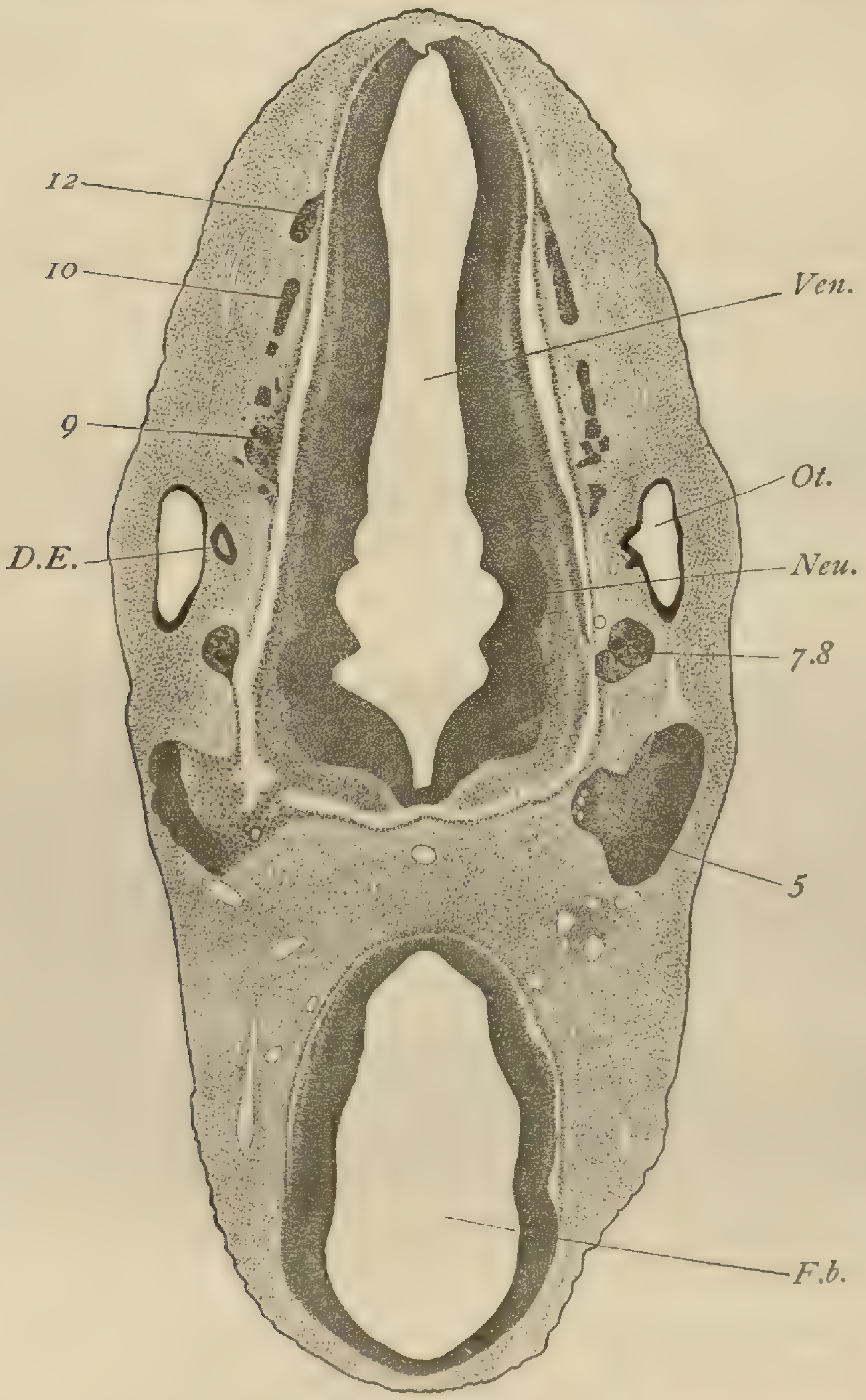


FIG. 2. — Pig embryo of 12.0 mm. Series No. 5. Transverse section 185. *D.E.*, ductus endolymphaticus; *F.b.*, fore-brain; *Neu.*, neuromere; *Ot.*, otocyst; *Ven.*, hind-brain (fourth ventricle); *5*, trigeminal nerve; *7.8*, acustico-facial nerve; *9*, glossopharyngeal nerve; *10*, vagus nerve; *12*, hypoglossal nerve. × 22 diams.

Fig. 2 is at a level about halfway between the eye and the highest point in Fig. 1; it passes, therefore, through the fore-brain (*F.b.*) and the fourth ventricle (*Ven.*) or cavity of the

hind-brain. The section is bounded by the thin layer of epidermis, between which and the brain-walls there is a large amount

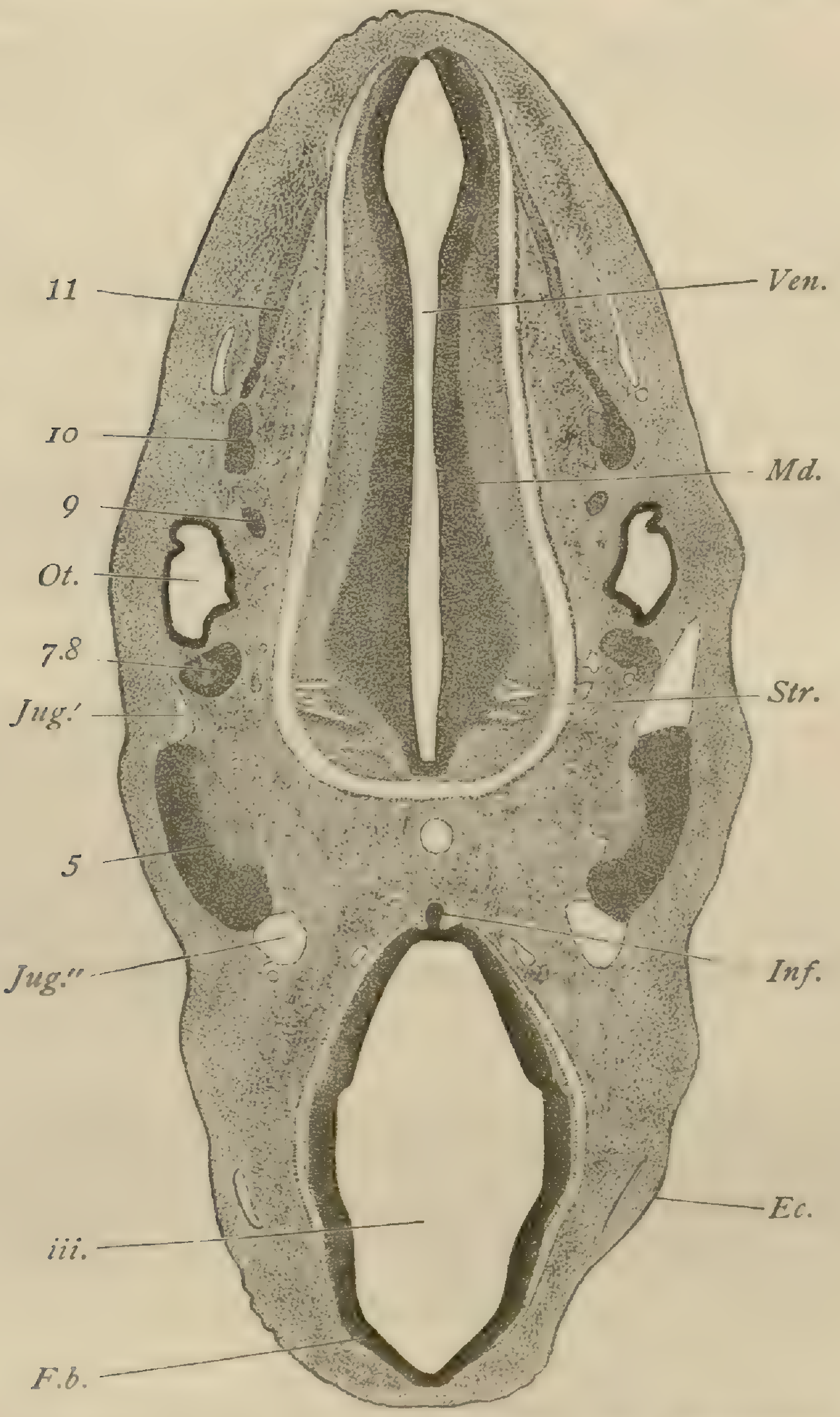


FIG. 3. — Pig embryo of 12.0 mm. No. 5. Transverse section 195. *Ec.*, ectoderm; *F.b.*, fore-brain; *Jug.'*, *Jug."*, jugular vein; *Inf.*, infundibular gland; *Md.*, medulla oblongata; *Ot.*, otocyst; *Str.*, striæ acusticæ; *Ven.*, cavity of hind-brain; *5*, trigeminal ganglion; *7.8*, acustico-facial complex; *9*, glossopharyngeus; *10*, vagus; *11*, accessarius; *iii.*, third ventricle of the brain. × 22 diams.

of mesenchymal tissue. Alongside the hind-brain lie a series of important structures imbedded in the mesenchyma, which

are identical upon the two sides, although they differ in the section, as the plane of cutting was not symmetrically transverse for the head. These structures are in the following order: *5*, the trigeminal ganglion; *7.8*, the acustico-facial ganglion complex; the otocyst, *Ot.*, with upon one side the separated ductus endolymphaticus, *D.E.*, and upon the other side the opening of the ductus displayed by the section; *9*, the glossopharyngeal ganglion; *10*, a portion of the vagus ganglion; *12*, one of the hypoglossal ganglia. Upon the left side of the figure the connection of the trigeminal ganglion with the angle of the wall of the hind-brain is demonstrated; by this connection and by its large size the trigeminal ganglion may always be identified in the embryo. The brain-wall has a thin outer layer both in the hind-brain and mid-brain; this is the outer neuroglia layer (Randschleier of His) and is conspicuous from the absence of stain; inside of the external layer the wall of the brain is crowded with nuclei, and therefore appears deeply stained in the preparation. Three neuromeres (*Neu.*) appear in the section, each marked by a concavity on the inner side of the brain-wall.

Fig. 3 is from section 195, and therefore ten sections below Fig. 2. It is given to show three points not shown in the preceding illustration: 1, the spinal accessory nerve root (*II*) arising from the cervical (in the figure, upper) end of the hind-brain and running forward to join the vagus ganglion; 2, the trigeminal ganglion with the internal jugular vein, which is cut twice (*Jug.'*, *Jug.''*), abutting close against it, — a very characteristic relation (this vein takes a sinuous course along the side of the hind-brain, for it passes inside the twelfth, eleventh, tenth, and ninth nerves, then outside the otocyst and the seventh-eighth nerve, and inside the fifth); 3, the infundibular process or gland (*Inf.*), springing from the floor of the fore-brain (*F.b.*). Attention may also be called to the structures (*Str.*), resembling the striæ acusticæ, but which seem to be rather the fibres of the lateral root of the facial.

The next figure (4) is from a lower level. The section passes through the eyes, the upper end of the auditory cleft (Fig. 1, *Au.*), and the upper cervical region of the spinal cord. The

spinal cord is clearly divided into a dorsal (*D.Z.*) and a ventral zone (*V.Z.*) on each side; the two dorsal zones are connected

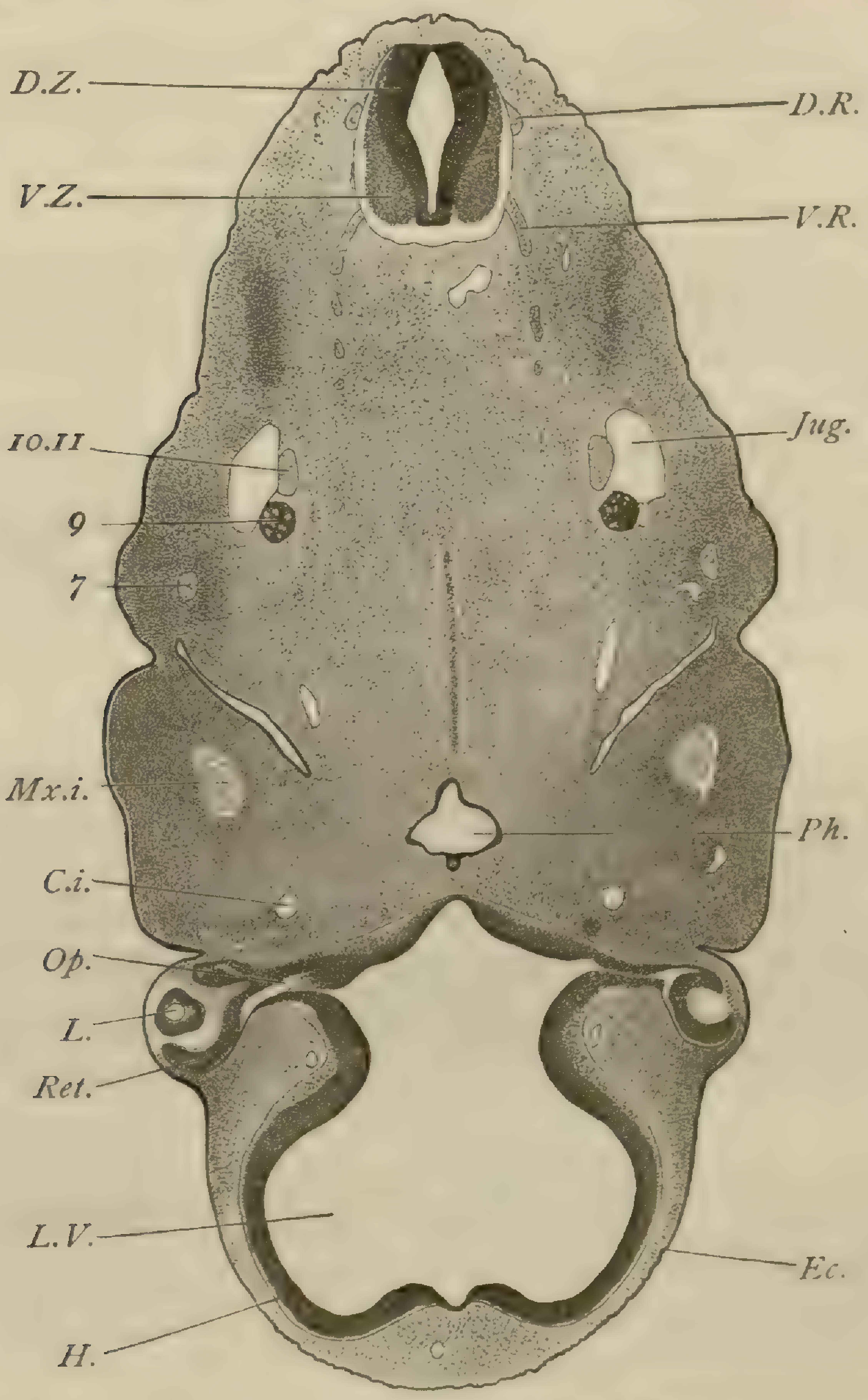


FIG. 4. — Pig of 12.0 mm. No. 5. Transverse section 245. *C.i.*, internal carotid artery; *D.R.*, dorsal root of spinal nerve; *D.Z.*, dorsal zone of spinal cord; *Ec.*, ectoderm; *H.*, cerebral hemisphere; *Jug.*, internal jugular vein; *L.*, lens; *L.V.*, lateral ventricle; *Mx.i.*, inferior maxillary nerve; *Op.*, optic nerve; *Ph.*, pharynx; *Ret.*, retina; *V.R.*, ventral root of spinal nerve; *V.Z.*, ventral zone of spinal cord; 7, facial nerve; 9, glossopharyngeal ganglion; *10.11*, vagus accessorius nerve. × 22 diams.

across the median line by the thin deck plate, and the ventral zones similarly by the thin floor plate. The lower or ventral limit of the dorsal zone is marked externally by the entrance of

the dorsal or ganglionic root, internally by the lateral angle of the central cavity, shown in the section. In the ventral zone the development is more advanced, — the three primary layers in the walls of the neuraxis (or medullary tube) being clearly differentiated, namely: the light outer neuroglia layer; the middle layer, commonly called the mantle layer, but which might be better named the neurone layer; and, finally, the innermost or ependymal layer. These three layers are primary and appear throughout the entire brain and spinal cord. The separation of the dorsal and ventral zones is of fundamental morphological importance, and their characteristics must be clearly understood before the anatomy of the brain is studied. The ventral zone contains all the neurones from which fibres arise forming the ventral nerve root (*V.R.*). Following downwards in the figure we come to the section of the jugular vein (*Jug.*), just inside of which lies the common trunk (*10.11*) of the united vagus and accessorius nerves, and also the lower part of the glossopharyngeal ganglion (*9*). Lower down and nearer the ectoderm lies the facial nerve (*7*), and again still lower is the large trunk of the inferior maxillary (*Mx.i.*), or mandibular branch of the trigeminal nerve. Between the two nerves last mentioned is a long oblique slit, which is found at another level to communicate with the pharynx (*Ph.*); this slit is the inner or entodermal portion of the first or auditory gill-cleft, and is the anlage of both Eustachian tube and of the cavity of the tympanum. Its outer (in Fig. 4, upper) end lies near the bottom of an ectodermal groove; this groove (Fig. 1, *Au.*) divides the mandibular process from the hyoid arch, and is the anlage of the meatus auditorius externus. The hyoid arch is marked in Fig. 4 by the facial nerve (*7*) and the arched overlying ectoderm. The internal carotid artery (*C.i.*) appears near the optic nerve (*Op*). External to this artery lies the superior maxillary nerve, which, however, does not show in the figure. The vesicular lens (*L.*) and the cup-shaped retina (*Ret.*) of the eye can be readily identified. The fore-brain has begun to form two lateral expansions, the cavities of which ultimately become the lateral ventricles (*L. V.*) of the brain, and the walls of which are the anlages of the hemispheres (*H.*).

Fig. 5 is from section 321, and is therefore considerably lower down in the series than the section represented in

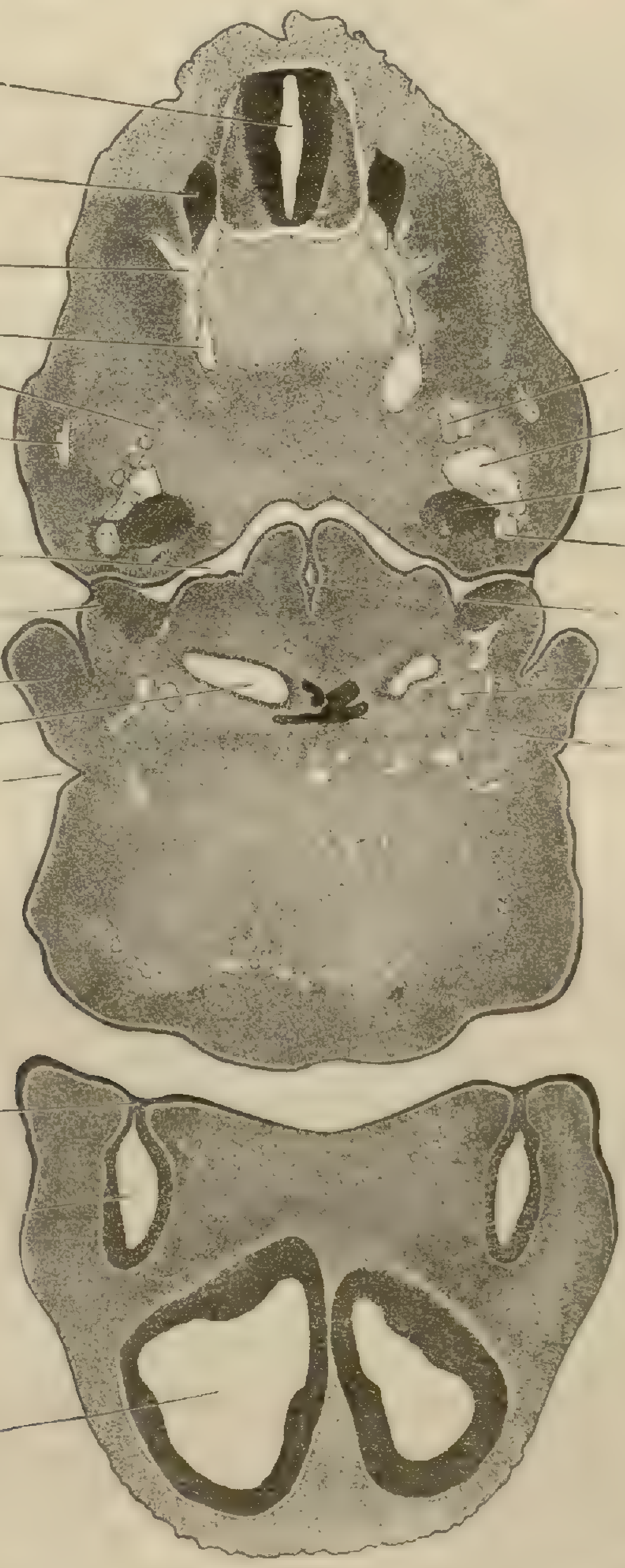


FIG. 5. — Pig of 12.0 mm. No. 5. Transverse section 321. *Ao.4*, fourth aortic arch; *Au.*, ectodermal depression of the first or auditory gill-cleft; *Cerv.1*, first cervical nerve; *Cerv.2*, ganglion of the second cervical nerve; *G.nod.*, ganglion nodosum (lower vagus ganglion); *Hy.*, hyoid arch; *Jug.*, jugular vein; *L.V.*, lateral ventricle; *M.th.*, median thyroid duct; *Na.*, nasal pit; *Nv.2*, second cervical nerve; *N.xii.*, hypoglossal nerve; *N.xi.*, spinal accessory nerve; *Ol.pl.*, nasopharyngeal plate; *R.ex.xi.*, ramus externus accessorii; *Sp.C.*, spinal cord; *Thyr.*, median thyroid; *Thm.*, thymus; *Ve.*, vein; *iii.*, third gill-cleft of the right side. × 22 diams.

Fig. 4. It passes through the cervical sinus and olfactory pits (compare Fig. 1), and therefore also through the spinal cord of the neck. The section comprises two distinct unequal parts:

the first and larger is the section of the cervical, pharyngeal and mandibular regions; the second and smaller is the section from the tip of the low bent head. The spinal cord (*Sp.c.*) in the upper part shows clearly both the three primary layers of its walls and the division into dorsal and ventral zones. The outermost layer is very lightly stained, and may be, perhaps, best defined as the anlage of the white matter. The inner layer is deeply stained, while the middle layer (mantle or gray stratum) is intermediate in color. The nerve cells develop most abundantly and rapidly in the ventral part of the mantle layer, which is consequently more enlarged than the dorsal part and has caused a bulging sidewards and downwards of the ventral zone. The ganglion (*Cerv.2*) is the second cervical; it sends a root upward to enter the dorsal zone of the spinal cord, and a tract downward to join the ventral root, thus constituting the second spinal nerve (*Nv.2*), which subdivides almost at once into a dorsal and a ventral ramus. Between the dorsal summit of the ganglion and the spinal cord there is a small bundle of nerve fibres, not shown in the figure. These fibres constitute the commissural trunk of the eleventh nerve. The third gill-cleft (*iii.*) is cut almost symmetrically, and extends from the median line to the edge of the section; it is lined throughout by the entoderm, which at the end of the cleft on each side has met and fused with the ectoderm to form an epithelial membrane (Verschlussplatte), which closes the cleft laterally. All vertebrate embryos probably have their gill-clefts at an early stage all closed by a similar membrane; but, whereas in fishes and amphibians the membrane is soon broken through, in mammals, on the contrary, it remains intact, and the clefts are, it is thought, normally always imperforate. At the end of the cleft the entoderm has undergone a special growth, forming a distinct mass (*Thm.*) on the side of the cleft towards the head. This entodermal structure is the anlage of the thymus, and is already penetrated by small blood vessels, which are perhaps not capillaries but sinusoids. The third gill-cleft extends to the bottom of the cervical sinus, a large and deep depression of the outer surface, clearly shown both in Figs. 1 and 5. The sinus is bounded cephalad by the large and

protuberant first or hyoid branchial arch (*Hy.*), and this arch is separated from the mandibular region by a groove (*Au.*) or ectodermal depression, which is later transformed into the meatus auditorius externus. In mammals there are four pairs of gill-pouches, or so-called clefts, all of which are lateral diverticula of the pharynx. Owing to the curvature of the pharynx these diverticula are brought to different levels, and into different planes in the pig embryo at the stage we are considering; hence in a series of sections the various gill-pouches are encountered in different portions of the series, and thus it occurs that only one pouch, the third, is shown in the section. The student should clearly understand that the median region of the two-thirds gill-pouches in Fig. 5 is the pharynx proper, and that it gives rise to the anlage of the median thyroid, of which both the stalk (*M.th.*) and the glandular portion (*Thyr.*) appear. Just above the third gill-cleft may be seen the large, darkly stained lower ganglion (ganglion nodosum) of the vagus nerve (*G.nod.*), and just above the ganglion is situated the section of the jugular vein (*Jug.*). Close to the ganglion on its ectal side appear two fibrous nerve trunks, of which the one nearest the pharynx is the accessorius or eleventh nerve (*N.x.i.*), while the other nearest the jugular vein is the hypoglossus, which reappears (*N.xii.*) below the aortic arch. A little above the jugular vein is the section of the first cervical nerve (*Cerv.1*), laterad from which is the external branch (*R.ex.xi.*) of the spinal accessory nerve. This branch in the adult innervates the sternocleido-mastoid and trapezius muscles.

The lower part of Fig. 5 represents part of the head and shows the two nasal fossæ (*Na.*) closed towards the mouth side by the olfactory plate (*Ol.pl.*), an epithelial membrane somewhat similar to the closing plate of a gill-cleft. On the dorsal side of the olfactory fossæ — below in Fig. 5 — the cerebral hemispheres are cut, their darkly stained wall bounding on each side the large lateral ventricle (*L.V.*).

The next section figured is No. 470, and is therefore much lower in the series. It was selected in order to show the anterior limb-buds, the ducts of Cuvier, and the heart. The

position and shape of the limb anlages are shown in Fig. 1, and the section demonstrates that they are formed by mesoderm, with a thin covering layer of ectoderm. The mesoderm is

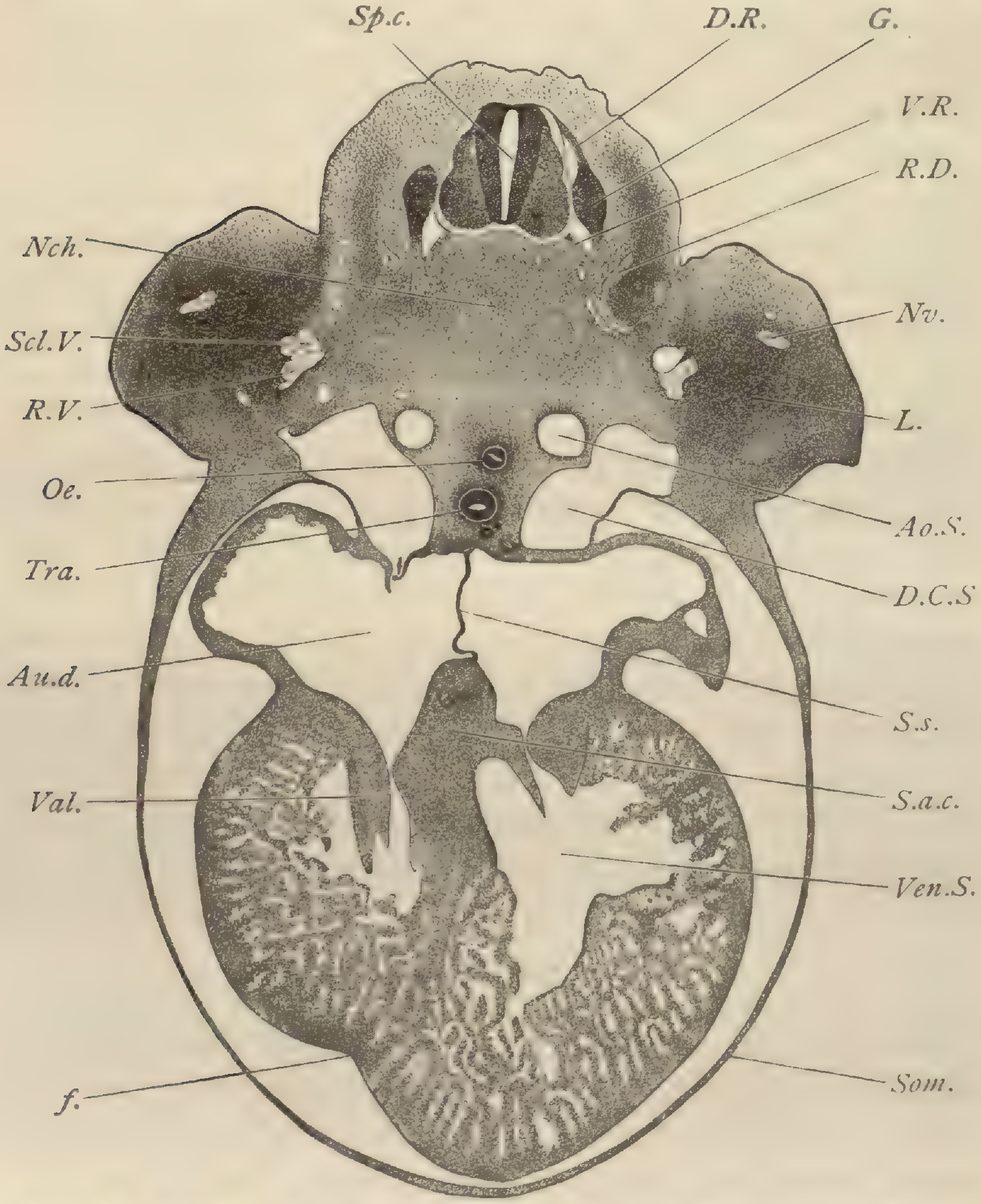


FIG. 6. — Pig of 12.0 mm. No. 5. Transverse section 470. *Ao.S.*, left dorsal aortic trunk; *Au.d.*, right auricle of the heart; *D.R.*, dorsal root of spinal nerve; *D.C.S.*, left ductus Cuvieri; *f.*, external groove between right and left auricles of the heart; *G.*, ganglion of spinal nerve; *L.*, anlage of fore-limb; *Nch.*, notochord; *Nv.*, nerve of limb; *Oe.*, œsophagus; *R.D.*, ramus dorsalis of spinal nerve; *R.V.*, ramus ventralis of spinal nerve; *S.a.c.*, septum of auricular canal; *Scl.V.*, subclavian vein; *Som.*, somatopleure; *Sp.c.*, spinal cord; *S.s.*, septum superius; *Tra.*, trachea; *Val.*, atrio-ventricular valve; *Ven.S.*, left ventricle; *V.R.*, ventral root of spinal nerve. × 22 diams.

very little differentiated, none of the skeletal elements being yet formed. The nerves and blood vessels are growing into

the limb; the nerves are the rami ventrales (*R. V.*) of spinal nerves, and form branches within the limb; one of these branches, as yet unidentified, is shown at *Nv.* The vein *Scl. V.* is the so-called subclavian or axillary vein, a branch of the jugular, as explained below. The lower part of the section is occupied by the large heart lying in the pericardial chamber. The body-wall (*Som.*), or somatopleure, which forms the outer covering of this chamber, is quite thin, and without a trace of muscular or skeletal structures. The heart consists of two auricles and two ventricles. The auricles have thin walls and are separated from one another by a very thin membrane, the septum superius (*S.s.*). The right auricle (*Au.d.*) receives upon its dorsal side the opening of the vein or duct of Cuvier, this opening being guarded by valves; of these valves, the one towards the median line disappears, but the other, towards the right of the embryo, persists to form both the Eustachian and Thebesian valves of the adult. The corresponding opposite vein, or left duct of Cuvier (*D.C.S.*), is almost symmetrically placed, but does not have any communication with the left auricle, being instead connected at a lower level by a transverse venous trunk with the ductus Cuvieri of the right side. The upper portion of the left duct (*D.C.S.*) is seen in the section to be somewhat constricted off from the lower portion, and in fact it shows the jugular vein of the head at its actual junction with the ductus. The ventricles of the heart are much larger than the auricles, and the left ventricle (*Ven.S.*) is already larger than the right; the external groove (*f.*), which marks the boundary between the two ventricles, is clearly shown by the section. The trabecular structure of the ventricles is well developed and affords a diagnostic mark by which the ventricles, however cut, may be easily recognized in sections. The development of the trabeculæ corresponds to the formation of the blood sinusoids of the heart, to which I have recently directed attention. The constricted region of the heart, which connects the auricles with the ventricles, is known as the auricular canal. A broad partition (*S.a.c.*) divides the canal into right and left channels, and at the ventricular ends of these channels the formation of atrio-ventricular valves

(*Val.*) is well advanced. The dorsal or trunk region of the section is formed chiefly by the more or less dense mesenchyma. It includes important structures. The spinal cord (*Sp.c.*) resembles that in Fig. 5, but is both larger and more differentiated. The fundamental morphological characteristics of a spinal nerve are well illustrated by the left nerve of Fig. 6. The dorsal root (*D.R.*) bears the ganglion (*G.*) and is joined a little below the level of the cord by the ventral root (*V.R.*) to form a single nerve trunk, which, however, soon subdivides into its two primary branches; the first or dorsal branch, ramus dorsalis (*R.D.*), bends at an acute angle upwards and outwards; the second or ventral continues downward and curves into the limb; owing to this curvature it must be traced through adjacent sections, but in Fig. 6 it can be seen again (*R. V.*) at the base of the limb, where it crosses the subclavian vein (*Scl.V.*). Some distance below the spinal cord is the small notochord (*Nch.*). Much lower, and between the two ducts of Cuvier, appear the œsophagus (*Oe.*) and trachea (*Tra.*), each a ring of entodermal epithelium with commencing condensation of surrounding mesenchyma. This condensed tissue is the anlage of the future submucosa and muscularis. Above the œsophagus, to the right and left, appears the dorsal aortic trunk, of which the left only (*Ao.S.*) is completely retained throughout life. It should be noted that the blood vessels, including the largest, have at this stage only endothelial walls, the adventitial and muscular coats being added later. *All* blood vessels are endothelial chambers, and this fundamental conception ought to be made clear to the student.

We now pass to a section (No. 633) well below the heart, in order to study the characteristics of the Wolffian body, stomach, and liver. At this level, as comparison of the figures will show, the body of the embryo has its greatest dimensions. The upper edge (*Um.*) of the umbilical cord also appears in this section. The spinal cord, with the ganglia and nerves, presents essentially the same features as in Figs. 5 and 6. The notochord (*Nch.*) forms a small circle in section and is surrounded by an area over which the mesenchymal cells are more crowded or condensed than elsewhere. The condensed

mesenchyma is the anlage of a vertebra (*Vert.*). It is more expanded laterally than dorso-ventrally. In the median line below the notochord is the large dorsal aorta (*Ao.*), which is

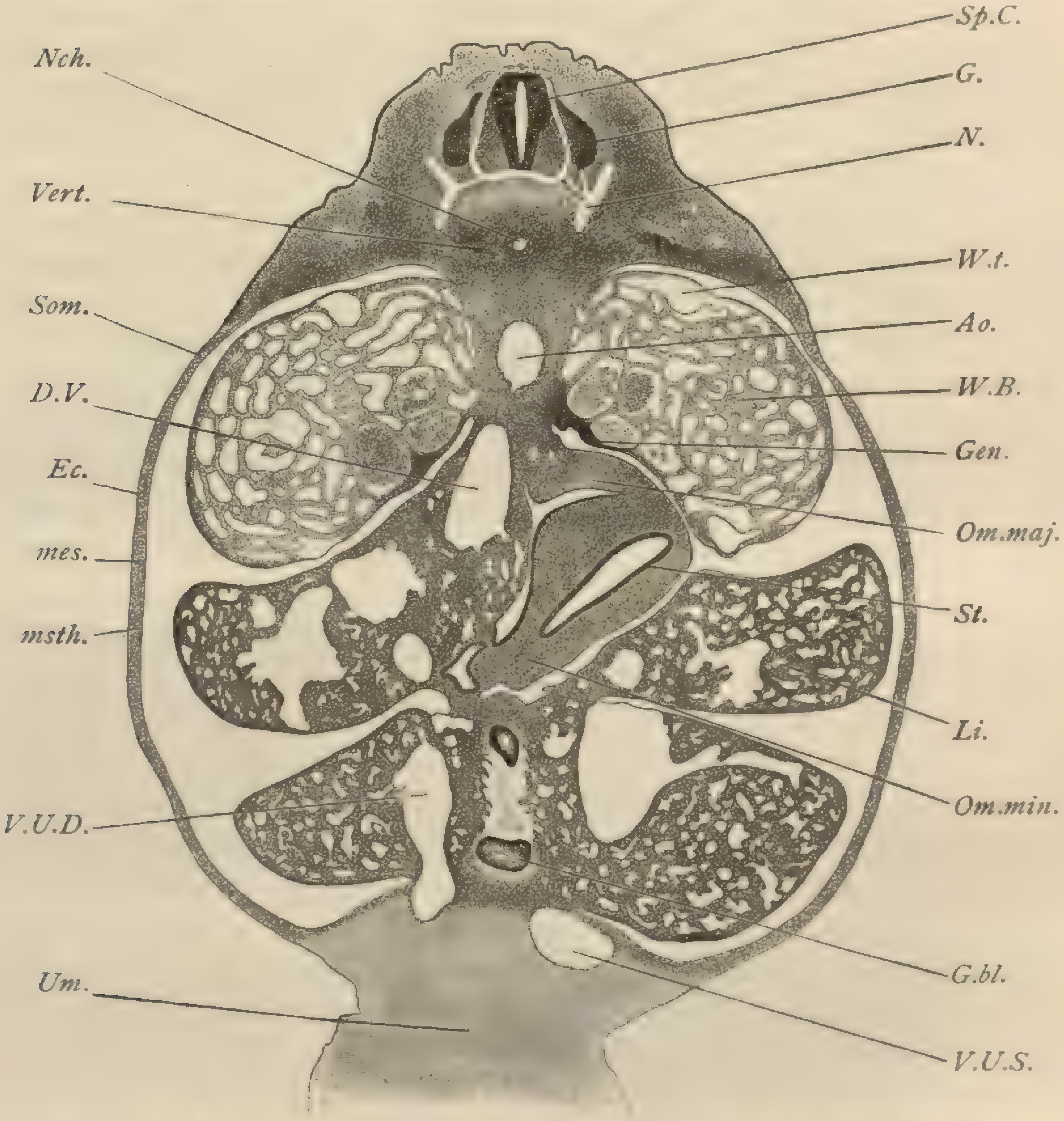


FIG. 7. — Pig of 12.0 mm. No. 5. Transverse section 633. *Ao.*, aorta; *D.V.*, ductus venosus; *Ec.*, ectoderm of the somatopleure; *G.*, ganglion on dorsal root of spinal nerve; *G.bl.*, gall bladder; *Gen.*, anlage of genital gland; *Li.*, liver; *mes.*, mesenchyma of somatopleure; *msth.*, mesothelium of the somatopleure; *Nch.*, notochord; *N.*, spinal nerve; *Om.maj.*, omentum major; *Om.min.*, omentum minus; *Som.*, somatopleure; *St.*, stomach; *Um.*, umbilical cord; *Vert.*, anlage of the body of a vertebra; *V.U.D.*, right umbilical vein; *V.U.S.*, left umbilical vein; *W.B.*, Wolffian body or mesonephros; *W.t.*, Wolffian tubule. × 22 diams.

formed by the union of the two dorsal aortic trunks of Fig. 6, and which extends through the abdominal region of the

embryo to the pelvis, where it forks to form the two allantoic arteries, which run to the umbilicus, and entering the umbilical cord supply the extra-embryonic or placental circulation. The aorta is surrounded by mesenchyma, and to this are, so to speak, appended the large Wolffian bodies (*W.B.*), one on each side. They are much larger, relatively to other parts, in the pig than in man or the rabbit. The Wolffian body is the fœtal or embryonic kidney, and is also termed the mesonephros. It consists of numerous epithelial tubules (*W.t.*), very much contorted, with blood spaces (sinusoids) between them, and of glomeruli, which always lie towards the median and inferior side of the organ. All of the tubules open into the single longitudinal canal, the Wolffian duct. This duct is always situated close to the surface on the ventral side of the organ, and is very easily distinguished in dissected embryos after the removal of the intestines and liver. In the figure it may be easily found in the left mesonephros (*W.B.*), it being there the lowermost of the cavities drawn. On the median lower surface of the Wolffian body, underneath the glomeruli, is an accumulation of tissue (*Gen.*), the anlage of the genital gland. Below the aorta, on the right of the embryo, is the large ductus venosus, or upper end of the vena cava inferior, on its way past the right dorsal lobe of the liver towards the heart. Below the aorta on the left is the mesogastrium (*Om.maj.*), or future great omentum, by which the stomach is suspended from the median dorsal wall of the abdomen. The stomach (*St.*) is entirely upon the left side of the body, and is directly connected by means of the anlage of the lesser omentum (*Om.min.*) with the liver. The liver is by far the largest organ of the body; it takes up nearly half of the section. It is divided into four main lobes, two dorsal and two ventral, two on the right and two on the left. The reference line (*Li.*) runs to the left dorsal lobe. The liver consists of a complicated network of relatively large blood sinusoids, the spaces between which are occupied by the embryonic liver cells. Near the median line between the ventral lobes appears the gall-bladder (*G.bl.*), which is cut three times. The liver is attached in the median ventral line to the body-wall

and the base of the umbilical cord. The two umbilical veins enter the liver directly from the cord. The right vein (*V.U.D.*) is already smaller than its left fellow (*V.U.S.*). They are connected respectively with the right and left ventral lobes of the liver. The right vein in a little later stage is no longer recognizable as an open channel. It will be noticed that the right and left sides of the abdominal cavity (splanchnocœle) are completely separated from one another, and that there is a special part of this cavity shown in the section between the stomach and the right dorsal lobe of the liver, and which is known as the lesser peritoneal space or cavity of the omentum. The body-wall (*Som.*), or somatopleure,[1] consists of three layers, — the ectoderm (*Ec.*), the mesenchyma (*mes.*), and the mesothelium (*msth.*). It is of the greatest importance for the student to understand the arrangement of the germ-layers in the somatopleure. The mesothelium (*msth.*) is commonly known in the descriptive anatomy of the adult as the peritoneal epithelium. In sections like that of Fig. 7 it can be followed not only over the inner surface of the body-wall but over the surface of the Wolffian body and liver, and upon the left side of the body also over the surfaces of the greater omentum, stomach, and lesser omentum. We see, in fact, that the body cavity is completely bounded by mesothelium, and that all the abdominal viscera are therefore outside of it. This conception, which is so important yet so difficult to the student of anatomy, is easily mastered by the study of the embryonic relations.

From the sagittal series of the same stage many instructive pictures are obtainable. I have selected a median section of the head, and one passing through the principal cephalic ganglia, for engraving, and give here the latter. The magnification is 22 diameters, the same as for the transverse sections Figs. 2 to 7. To the student of anatomy such a section as is shown in Fig. 8 is highly instructive, for it exhibits in a single picture many important fundamental relations of the cephalic nerves, particularly of the second, fifth, seventh,

[1] It is much to be regretted that German embryologists use the term "somatopleure" erroneously.

eighth, ninth, and tenth. As the section is remote from the median plane, little of the brain appears, there being only a shaving from the lateral wall of the fore-brain (*H.*) and a section of the widest part of the hind-brain, which shows the cavity or lateral recess (*R.L.*) of the fourth ventricle. The auditory vesicle or otocyst (*Ot.*) is cut; its narrow upward prolongation is the anlage of the ductus endolymphaticus. The otocyst lies in a line with the great cephalic ganglion, occupying its invariable and permanent position behind the acustico-facial ganglion (*Ac.F.*) and in front of the glosso-pharyngeal. Only the lateral portion of the pharynx (*Ph.*) appears; this portion forms a wide diverticulum, almost slit-like (compare Fig. 4), from which extend the first and second entodermal gill-pouches. In the figure the pharynx has a small depression extending downward at the œsophageal end of the part shown in the section; this depression marks the beginning of the second cleft. Nothing is seen of the third and fourth clefts in the section, as these both lie nearer the median plane. The pocket or diverticulum of the cervical sinus (compare Fig. 1) appears (*Cerv.S.*) near the ganglion nodosum (*G.nod.*). It might be mistaken for a gill-cleft, but it is lined by ectoderm and its cavity can be easily traced through the series to the exterior. Cephalad from the sinus but close to it lies a small dark mass, the anlage of the thymus gland. The mass is produced by proliferation of the entodermal cells on the anterior side of the third cleft (compare Fig. 5, *Thm.*), and is penetrated by blood vessels which seem to be sinusoids, although their history has not been worked out. The jugular vein (*Jug.*), owing to its irregular course, is cut several times; its main stem (*Jug.''''*) rises nearly vertically through the cervical region, and is, relatively to the size of the embryo, of huge diameter, and continues (*Jug.'''*) upward along the dorsal side of the vagus nerve to a level about halfway between the ganglion nodosum and ganglion jugulare, and as the vessel there curves inwards and forwards it is not encountered again until it bends outwards (*Jug.'*) on its way past the trigeminal ganglion. A branch of the jugular vein (*Jug.''*) is cut just above the ganglion.

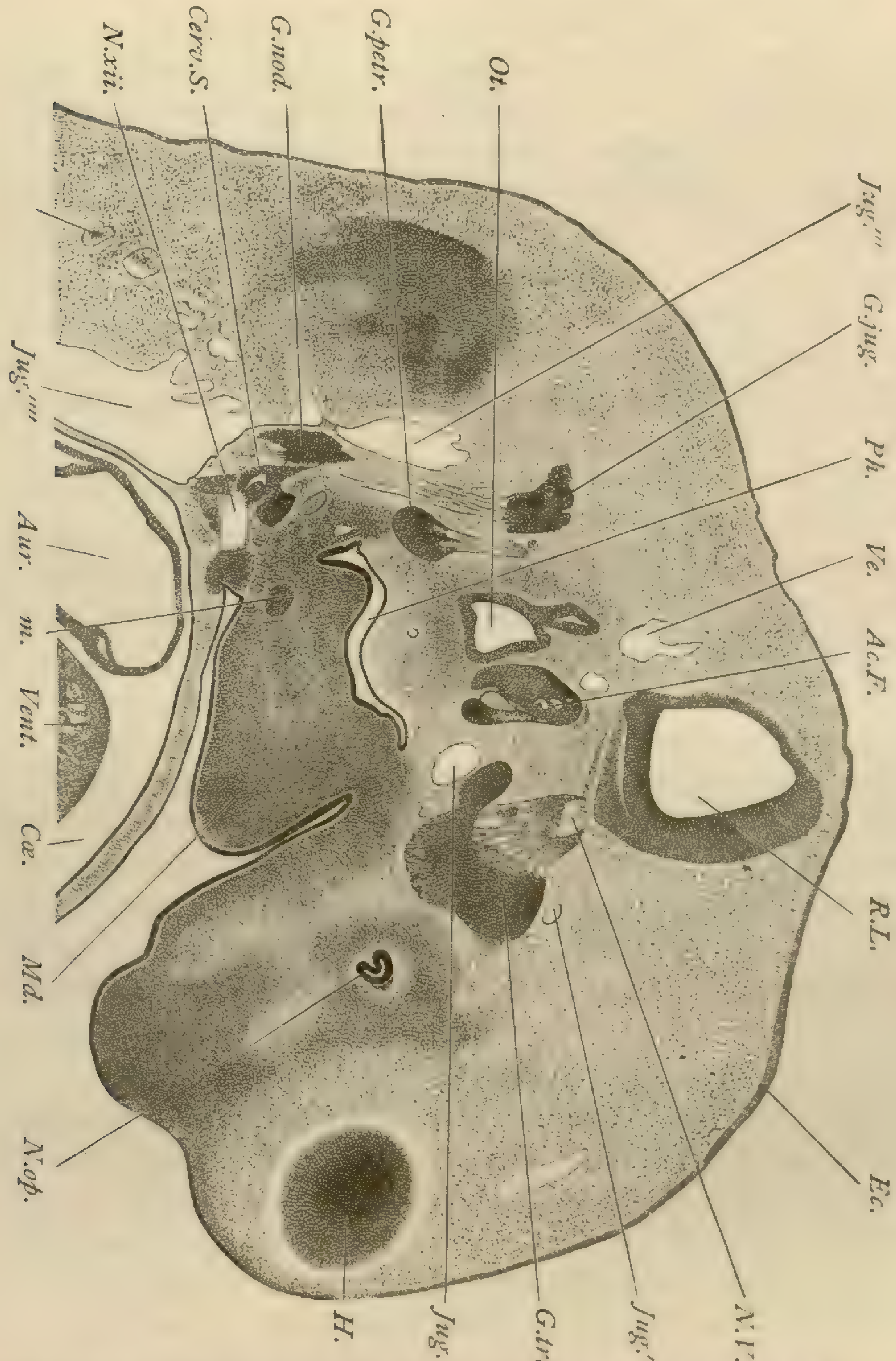


FIG. 8. — Pig of 12.0 mm. No. 7. Sagittal section 25. *Aur.*, auricle of the heart; *Ac.F.*, acustico-facial ganglion complex; *Cœ.*, cœlom around the heart or pericardial cavity; *Cerv.S.*, diverticulum of the cervical sinus, just in front of which shows the anlage of the thymus, which is deeply stained; *G.jug.*, ganglion jugulare of the vagus nerve; *G.nod.*, ganglion nodosum of the vagus nerve; *G.petr.*, ganglion petrosum of the glossopharyngeal nerve; *G.tri.*, ganglion of the trigeminus nerve; *H.*, lateral wall of the cerebral hemisphere; *Jug.*, jugular vein; *Jug.'*, behind the trigeminus; *Jug.''*, branch in front of the trigeminus; *Jug.'''*, main stem behind the vagus; *Jug.''''*, main stem descending to join the duct of Cuvier; *m.*, an undetermined structure, probably the anlage of a lingual muscle; *Md.*, mandible; *N.V.*, root of the fifth or trigeminal nerve; *N.op.*, optic nerve; *N.xii.*, twelfth or hypoglossal nerve; *Ot.*, otocyst; *Ph.*, pharynx; *R.L.*, recessus lateralis of the fourth ventricle; *Ve.*, small branch of the jugular vein; *Vent.*, ventricle of the heart. × 22 diams.

The nerves are shown as follows: The optic nerve (*N.op.*) still has its central cavity, which, nearer the median plane, opens into the third ventricle of the brain, and in the section resembles in shape an inverted U. On the side of the nerve towards the mouth there is a deep notch, — the section of the choroid fissure. The trigeminal ganglion (*G.tri.*) is very large, and its trilobate form is clearly indicated by the figure. The lobe to which the reference line (*G.tri.*) runs gives off the ramus ophthalmicus; the lobe nearest the jugular gives off the ramus maxillaris inferior, while the middle lobe gives off the ramus maxillaris superior. From the ganglion the fibres and nerve cells extend upwards to form the root (*N.V.*), which joins the hind-brain at a characteristic point,— namely, at the summit of the Varolian bend and where the hind-brain is widest (compare Figs. 2 and 3). By its great size and by its topographical association with the lateral apex of the recessus lateralis of the fourth ventricle, the trigeminal ganglion may always be readily identified in sections of embryos. The acustico-facial ganglia (*Ac.F.*) may also be readily determined by their typical position immediately in front of the otocyst (*Ot.*). But it is quite difficult to identify the four components of this complex structure, namely: 1°, the motor root of the facial nerve; 2°, the facial or geniculate ganglion; 3°, the vestibular ganglion; 4°, the cochlear ganglion. In Fig. 8 three divisions are shown. The large, darkly stained division, to which the reference line (*Ac.F.*) runs, and which lies nearest to the otocyst, is the vestibular portion of the acoustic ganglion; the small, light area occupying a middle position in the inferior part of the complex is the motor division of the seventh nerve, or lateral root of the facial; it can be followed to the brain, which it enters as four bundles of fibres; its path of entrance is shown better in frontal sections (Fig. 10). Just in front of the facial motor root lies a second smaller dark mass, the geniculate ganglion of the facial, with an upward prolongation, the sensory root. The ninth or glossopharyngeal nerve is represented by the ganglion petrosum (*G.petr.*) and its ascending sensory root. This nerve may be quickly identified because it is the first behind the otocyst. The upper ganglion of this

nerve, the so-called Ehrenritter's ganglion, is represented by an accumulation of cells in the upper part of this root. As regards the tenth nerve, or vagus, both its ganglia and the fibrous trunk connecting them are shown. The upper or jugular ganglion (*G.jug.*) is nearly on a level with the otocyst, while the lower or nodosal (*G.nod.*) lies near the cervical sinus. To the nerve trunk between the two ganglia are adjoined the fibres of the eleventh or spinal accessory nerve, which does not otherwise appear in this section. A small piece only of the hypoglossal nerve can be seen (*N.xii.*). The space occupied by this nerve is blank in the engraving; in the specimen it shows horizontal fibres.

The frontal series has special value for the study of the hind-brain, its nerves, and of the otocyst. From this series I present here three figures of the head region. The first of these sections (Fig. 9) passes through the widest part of the hind-brain and through the roots of the trigeminus. The cavity of the hind-brain is enormously distended; it is bounded on the dorsal side only by a very thin layer of cells, the epithelial roof or ependyma (*Ep.*), which does not form part of the true nervous structures, although it passes into and is directly continuous with the dorsal zone (*D.Z.*) of the medulla oblongata, which is thus seen (also in Figs. 10, 11) to be only the thickened ventral wall of the neural tube, just as the ependyma is the attenuated dorsal wall. The trigeminal ganglion (*G.tri.*) is very large and sends its sensory fibres

FIG. 9.—Pig of 12.0 mm. Series No. 6. Frontal section 284. *Ec.*, ectoderm; *Ep.*, ependymal roof of the fourth ventricle; *D.Z.*, upper portion of the dorsal zone of His; *G.tri.*, ganglion trigemini; *Jug.*, jugular vein; *L.R.*, lateral root of the trigeminal nerve; *mes.*, mesenchyma; *T.S.*, tractus solitarius of W. His. × 22 diams.

upwards into the dorsal zone to form there the tractus solitarius (*T.S.*). Its motor or lateral root (*L.R.*) is below the ganglion and nearer the median line. As it enters the brain it curves and as a still distinct bundle runs towards the median plane. Its similarity to the motor root of the facial is very striking, but so far as I am aware has not been recorded hitherto (compare Figs. 9, 10). Inside of the trigeminal ganglion lies the jugular vein.

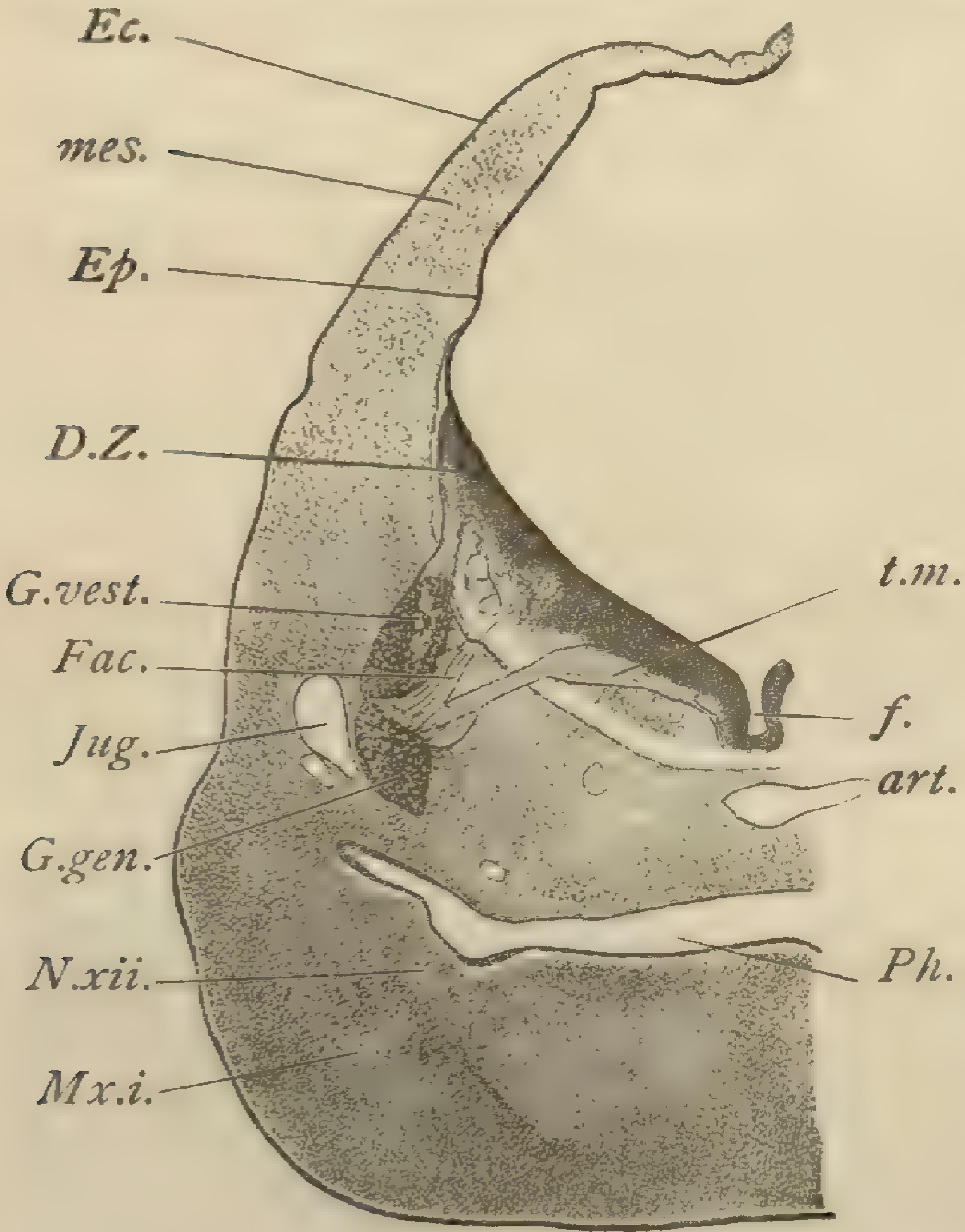


FIG. 10. — Pig of 12.0 mm. No. 6. Frontal section 340. *art.*, arteria basilaris; *D.Z.*, dorsal zone of the medulla oblongata; *Ec.*, ectoderm; *Ep.*, ependymal roof of the fourth ventricle; *f.*, median fissure of the medulla oblongata; *Fac.*, sensory root of the facial nerve; *G.gen.*, geniculate ganglion of the facial nerve; *G.vest.*, ganglion vestibuli of the acoustic nerve; *Jug.*, jugular vein; *mes.*, mesenchyma; *Mx.i.*, inferior maxillary branch of the trigeminal nerve; *N.xii.*, hypoglossal nerve; *Ph.*, pharynx; *t.m.*, motor tract of facial nerve. × 22 diams.

The next figure (Fig. 10), through the acustico-facial ganglion, shows the thickened ventral wall of the hindbrain (*i.e.*, the anlage of the medulla oblongata) no longer spread out nearly horizontally, but rising obliquely from the median line. The right and left sides of the medulla oblongata are divided from one another by a deep median fissure (*f.*). In the median line just below appears the basilar artery (*art.*), and still lower the wide, slit-like pharynx (*Ph.*), the outer portion of which ascends obliquely towards the jugular vein. The ascending part is a portion of the first gill-pouch (future Eustachian tube) and is quite clearly marked off from the pharynx proper. Of the acustico-facial complex the section shows four parts: the ganglion vestibuli (*G.vest.*); the geniculate ganglion (*G.gen.*); the sensory root (*Fac.*) of the facial nerve arising from the geniculate ganglion and entering the brain to form there a distinct

fibre tract, which is oval in section, lies just below the entering vestibular fibres, and is indicated in the engraving; finally, the motor tract (*t.m.*) of the facial; this tract is a very distinctly marked bundle of nerve fibres, which traverse the ventral zone of the medulla almost horizontally, then come downwards and, passing out from the brain-wall, form the *lateral* root of the facial; this root runs first towards and then past the geniculate ganglion. The jugular vein (*Jug.*) lies outside the ganglia, not inside, as in Fig. 9. In the mandible appear two nerves; of these the upper is the hypoglossal (*N.xii.*); it lies near the angle formed by the junction of the first gill-cleft with the pharynx proper; the lower is the inferior maxillary.

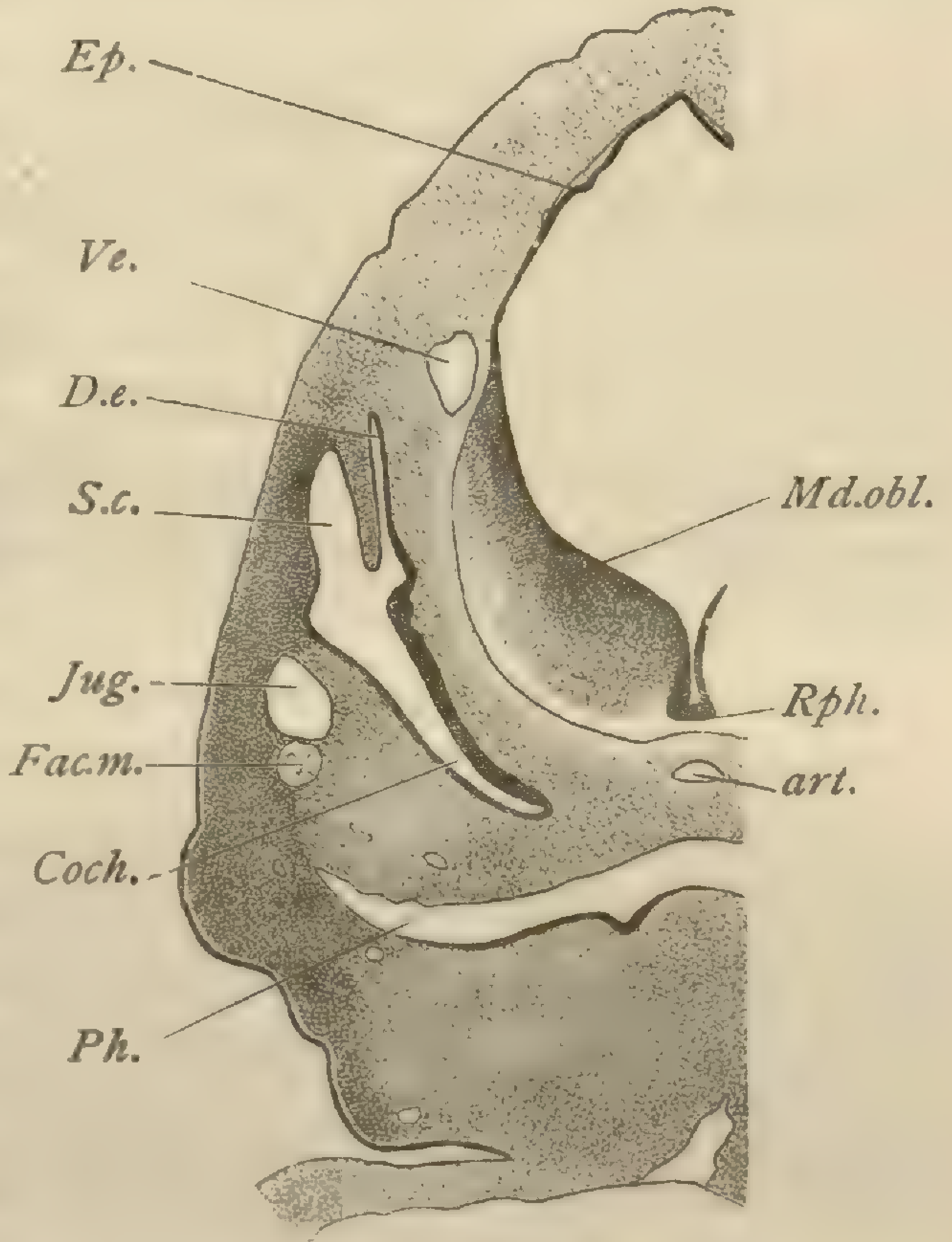


FIG. 11. — Pig embryo of 12.0 mm. No. 6. Frontal section 380. *art.*, artery; *Coch.*, cochlea; *D.e.*, ductus endolymphaticus; *Ep.*, ependyma; *Fac.m.*, motor division of the facial nerve; *Jug.*, jugular; *Md.obl.*, medulla oblongata; *Ph.*, pharynx; *Rph.*, median raphe of the medulla oblongata; *S.c.*, anlage of the semicircular canals; *Ve.*, vein. × 22 diams.

The next figure is from a section not far from the last and chosen to show the otocyst. The hind-brain has narrowed considerably; its thickened floor (*Md. obl.*), the anlage of the medulla oblongata, rises steeply from the median line; its ependymal roof (*Ep.*) is less expanded than in Figs. 9 and 10 and forms a sharp angle in the dorsal median line. The two sides of the medulla are separated by a deep fissure (*cf.* Fig. 10, *f.*), underneath which the wall of the brain is correspondingly thinned, constituting the floor plate (*Rph.*), which is transformed in the adult into the median raphe. The pharynx (*Ph.*) is wide and is expanded laterally into the common

beginning of the first and second gill-pouches. Between the pharynx and the raphe the basilar artery (*art.*) has been cut transversely. The otocyst is a large epithelial vesicle with three well-marked divisions: first, the common chamber (*S.c.*), out of which the three semicircular canals are to be differentiated; second, the slender canal (*D.e.*), the anlage of the ductus endolymphaticus, which lies between the semicircular canals and the medulla; third, the long, curving, but not spiral, cochlea (*Coch.*). The common chamber formed by the union of these three divisions is later subdivided to form the upper utriculus and lower sacculus. Outside the cochlea lies the cross-section of the jugular vein (*Jug.*), just below which is the section of the motor portion (*Fac.m.*) of the facial nerve. The sensory portion of the facial is much smaller, runs only a short distance downwards from the geniculate ganglion, and is entirely separate from the motor portion. It seems to me, therefore, that the anatomical description of this nerve, in view of the embryonic conditions, needs revision.

The absence of advanced stages of histological differentiation at this period of development is a general and characteristic state of the tissues. Especially noteworthy is the simple character of the mesenchyma, for it offers no marked differentiation except that of the merely endothelial blood vessels and their contained blood. The blood corpuscles are all nucleated red cells, which are for the most part in embryos of twelve millimeters, in a transitional stage. In younger pigs the corpuscles are in the ichthyopsidan stage and have a full-sized nucleus with quite distinct chromatin granules. In older pigs the corpuscles have much-contracted nuclei, which stain darkly, as in the blood cells of Sauropsida. In our embryo the nuclei are partly contracted and modified. The mesenchyma proper is very voluminous and constitutes a large proportion of the total bulk of the body. Its cells vary much in the degree in which they are crowded in the different territories of the tissue, and they vary also in form, but they can hardly be said to offer any positive specialization, and there is probably at this stage no differentiation of the fibrils and elastic networks, which are so conspicuous in many of the adult tissues which are derived

from the embryonic mesenchyma. The simplicity of mesenchymal structure is further emphasized by the absence of distinct layers. Thus, between the brain and the ectoderm there is a continuous layer of tissue nearly uniform in appearance; later, out of this layer there will have arisen the cutis, subcutaneous tissue, periosteum, bone, dura mater, arachnoid, and pia mater, while the complexity of organization will have been increased by the ingrowth of nerves and striated muscles. The entoderm and ectodermal epidermis are both quite simple epithelial structures, although the entoderm, it must be added, already presents some very important modifications, such as the notochord, the thymus and thyroid glands, and the liver. On the other hand, the neuro-ectoderm shows advanced differentiation of the neurones with their accompanying axons, from the neuroglia cells. The mesothelium also offers more complexity, owing to its share in the development of the striated muscles, of the Wolffian body, and of the genital glands.

The preceding illustrations and descriptions are published, partly in the hope that in spite of their fragmentary character they will prove useful to some students of mammalian embryology, partly in the hope that the author will receive from other teachers criticism and suggestions in regard to the proposed text-book.

Harvard Medical School, Boston, Mass.
October 23, 1900.

ORIGIN OF THE MAMMALIA, III. OCCIPITAL CONDYLES OF REPTILIAN TRIPARTITE TYPE.[1]

HENRY FAIRFIELD OSBORN.

The Huxleyan theory of the origin of Mammalia (Huxley, '80) from primitive Amphibia is still entertained by Howes ('87); it has recently been revived by Hubrecht ('97) upon the basis of the fœtal membranes, and by Kingsley ('99) upon the basis of the homology of the quadrate and upon other grounds. The position taken by the present writer ('98, '99) is that the weight of evidence favors the derivation of the Mammalia from some unknown member of the Anomodont reptiles (Theriodontia) of Permian or lower Triassic age.

One of Huxley's arguments for amphibian ancestry ('80) was that the paired exoccipital condyles of the mammals were derived from similar amphibian structures. This is cited by Kingsley. The object of the present paper is to show that the *mammalian occipital condyles arose from a reptilian tripartite type by the reduction of the median basioccipital element and the expansion of the lateral exoccipital elements.*

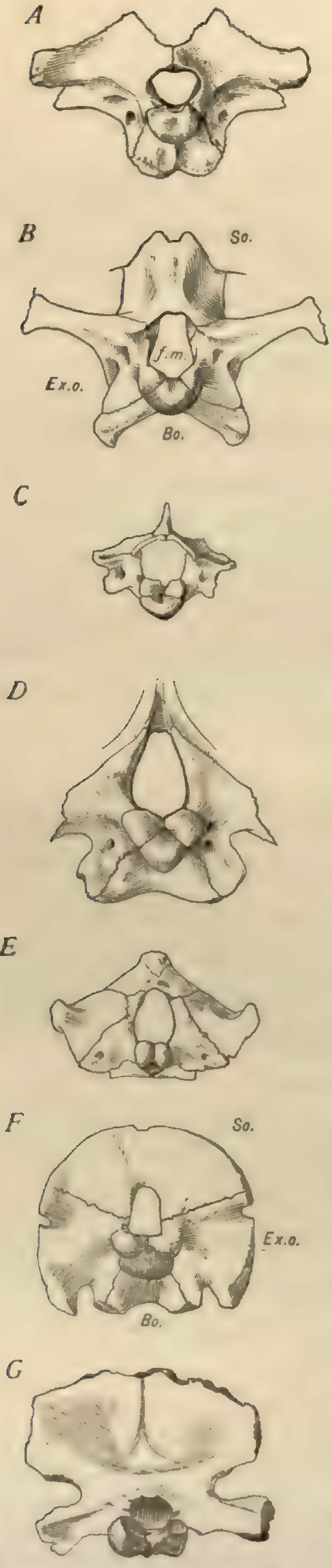
Types of Condyles.

The terms "monocondylia" and "dicondylia" employed by Cope fail to express the facts, for the junction of the basal elements of the skull with the atlas vertebra is of four types, — I, II, III, IV, as follows:

I. *Monocondylic, Typical*

Single basioccipital condyle, exoccipitals not entering into articulation . . . . Reptilia (*e.g.*, Alligator, Ichthyosaurus)

[1] Presented before Section of Zoölogy, American Association for the Advancement of Science, June, 1900. Contributions I and II upon the Origin of Mammals are cited in the bibliography.



II. *Monocondylic, Tripartite.*
Single condyle, basi- and exoccipitals in different proportions.
Reptilia (*e.g.*, Chelone, Fig. 1, *B*, *C*, *D*, *E*).

III. *Dicondylic, Transitional.*
Paired condyles, chiefly exoccipital, partly basioccipital.
Reptilia (*e.g.*, Cynognathus, certain Mammalia).

IV. *Dicondylic, Typical.*
Paired exoccipital condyles, basioccipital element cartilaginous or reduced in median line.
Amphibia (Rana, Mastodonsaurus) and certain Mammalia.

The above types are arranged morphologically, not genetically. Seeley ('88, p. 100) has pointed out the significance of the morphological transition from I to IV as consisting in the reduction of the basioccipital and enlargement of the exoccipital elements; he concludes: "Hence it is possible that the condylar cranial characters may be related in an evolutionary sequence of gradation, and that the change from one condition to another may be consequences of one plan of vertebrate organization rather than that of entirely independent plans."

The diagrams (Fig. 1) have been prepared to illustrate the transition between these types. They show that in the alligator the condyle is wholly basioccipital and below the foramen magnum. In the lizard, python, and two genera of Chelonia we observe a gradual expansion of the exoccipitals and reduction

FIG. 1. — Reptilian condyles. *A*, *Alligator lucius*; *B*, *Iguana tuberculata*; *C*, *Python reticulatus*; *D*, *Chelone midas*; *E*, *Testudo polyphemus*; *F*, Dicynodon (after Lydekker); *G*, Cynognathus (after Seeley). *A–D*, tripartite condyle, typical; *E–G*, reduction of basioccipital element. *Bo.*, basioccipital; *Ex.o.*, exoccipital; *f.m.*, foramen magnum; *So.*, supraoccipital.

of the basioccipital; other Chelonia are typically monocondylic. In like manner certain Anomodontia (Theriodontia) are typically monocondylic; others have a tripartite condyle as figured in Dicynodon (*F*); others again have a tripartite V-shaped condyle with the foramen magnum lying between the exoccipital portions; finally, in Cynognathus (*G*), we have two prominent convex condyles on the lower sides of the foramen magnum composed chiefly of the exoccipitals.

It is from the latter type, in our opinion, that the mammalian structure was probably derived.

But it is first necessary to demonstrate why the apparently obvious derivation of the mammalian from the amphibian condition is improbable.

We do not know the origin of the condyles in the Amphibia; all we know is that as soon as the occipital region becomes osseous, the most primitive amphibians show paired exoccipital condyles with a median cartilaginous or reduced basioccipital element; the reduction of the basioccipital is almost a class character. No Amphibia, so far as known to the writer, exhibit any participation of the basioccipital in the formation of the condyle.

On the contrary, many of the mammals show an extensive participation of the basioccipital in the formation of the condyles; in fact, some mammalian condylar types might

FIG. 2. — Mammalian condyles.

almost be termed tripartite. This gradation between a tripartite or transitional dicondylic condition and the "typical dicondylic" condition in the mammals is very clearly shown in the second series of diagrams (Fig. 2), which show these structures as seen from below or in palatal view.

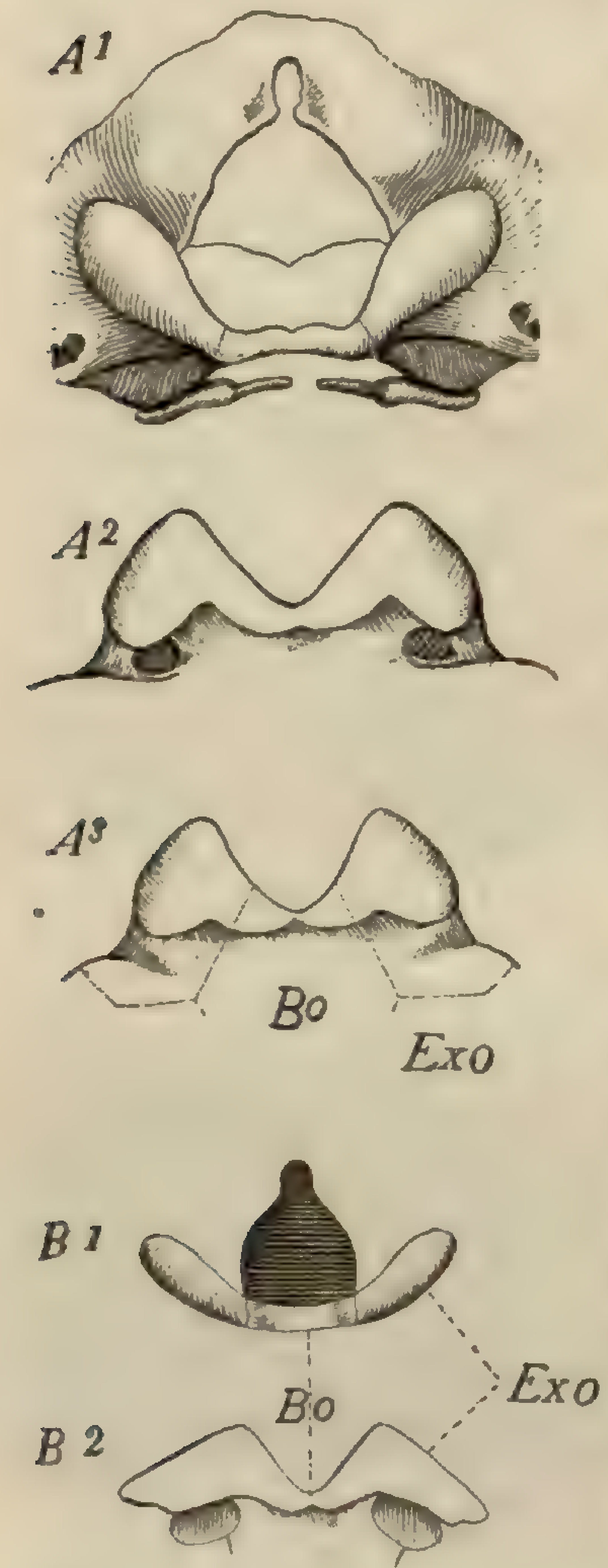


Fig. 3.—A^1–A^2, Echidna (Yale Museum, No. 300): A^1, from behind; A^2, from below; condyles joined by a broad cartilaginous bridge. A^3, Echidna (Yale Museum, No. 1691): from below; condylar surfaces barely separate. B^1–B^2, Ornithorhynchus: condylar ridges continuous; the cartilages are just separate when viewed from behind.

I am indebted to Mr. B. Arthur Bensley, Fellow in Zoölogy, Columbia University, for examining a large series of skulls in the American and Yale Museums (7 Monotremata, 12 Marsupialia, 15 Rodentia, 12 Carnivora, 7 Insectivora, 3 Cheiroptera, 4 Lemuroidea, 3 Anthropoidea, 3 Artiodactyla), with the following results:

Monotremata: The thickness of the basioccipital plates is a conspicuous feature of all monotreme skulls. (Yale Museum, Nos. 244, 300.) In three skulls of Echidna the exoccipital condyles are joined by a broad cartilaginous (basioccipital) bridge, very conspicuous after soaking in water (Fig. 3, A^1, A^2); in two skulls the condyles are joined by a narrow ridge; in two others (A^3) the condylar ridges are discontinuous. In Ornithorhynchus there is little variation in the condylar region (Fig. 3, B^1, B^2); the condylar ridge is continuous across the basioccipital region, the articular cartilages being slightly separate only when viewed from below. So far as this positive evidence goes, it is confirmatory of the theory of tripartite origin.

Marsupialia: The exoccipital condyles are distinct and separate in all forms examined except in Dasyurus, where there is a slight tendency to bridge the basioccipital (*D. maculatus*); this negative result is in keeping with the writer's theory of the *non-primitive* character of the marsupials.

Rodentia: The types examined give negative results.

Carnivora: A more or less distinctly tripartite condition is very common; Lynx, Mephitis, Taxidea, Lutra, Gulo, Putorius, Bassaris (Fig. 2) show all gradations in the participation of the basioccipital.

The conclusions are: (1), unlike reptiles, in no mammal does the basioccipital project backwards as far as the exoccipitals; (2), nevertheless the participation of the basioccipital in the condylar articulation is a common feature, and the monotremes present some grounds for considering it a primitive mammalian feature; (3), the weight of evidence is in favor of derivation from a tripartite type with a depressed basioccipital.

The evolution and gradation of the condyles in the Anomodontia (Theriodontia), from a typically monocondylic to a transitional dicondylic condition, in conformity with other mammalian structures in this order, tend to connect them with the hypothetical ancestral forms of mammals. Taken in connection also with the conditions we have been pointing out among living types, the reptilian tripartite origin of the mammalian condyles is rendered more probable than the amphibian dicondylic origin.

July 20, 1900.

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CONTRIBUTIONS FROM THE ZOÖLOGICAL LABORATORY OF THE MUSEUM OF COMPARATIVE ZOÖLOGY AT HARVARD COLLEGE. E. L. MARK, DIRECTOR. No. 117.

STUDIES ON THE CAUSE OF THE ACCELERATING EFFECT OF HEAT UPON GROWTH.

T. W. GALLOWAY.

THE following studies, directed toward a further analysis of the fact that the rate of growth of organisms varies with temperature, were made at the suggestion and with the guidance of Dr. C. B. Davenport. Growth, defined as increase in volume or mass, is evidently produced by one or both of the following processes: either (1) by imbibition of water, which results in an increase of cell sap, or (2) by assimilation, *i.e.*, anabolic metabolism, which results in the increase of plasma and of formed substance, such as starch, cellulose, etc. The question to which an answer was sought is this: In the acceleration of growth due to higher temperature, are imbibition of water and anabolic metabolism equally accelerated? or, if unequally affected, in which process is acceleration most marked?

The procedure embraced the following points:

1. Experiments were made upon the larvæ of *Rana sylvestris*, *Amblystoma punctatum*, and *Bufo americana*.

2. Fertilized eggs of a single spawning were subjected to three different temperature conditions: (1) 6°–8° C., (2) 12°–18° C. (12°–15° C. in Rana), and (3) 22°–25° C. (20°–24° C. in Amblystoma). The other conditions were as nearly as possible alike in the three cases.

3. No food was supplied other than that contained in the egg and in the albumen surrounding the embryo; consequently, these results apply only to the early stages of development in the amphibian embryo.

TABLE I. — RANA SYLVESTRIS.

Date.	No. of Days.	Length. mm.	Average Weight. mg.	Av. Wt. Dry Substance. mg.	Average Weight Water. mg.	Per cent of Dry to Whole Weight.
	1. Temperature 6°–8° C.					
March 23[1] . . .	—	—	3.98	1.50	2.48	37.5
April 5	13	5	4.46	1.49	2.97	33.4
" 8	16	6	5.04	1.58	3.46	31.3
" 11	19	7.5	6.12	1.64	4.48	26.8
" 16	24	10	8.26	1.58	6.68	19.1
" 19	27	10	9.50	1.54	7.96	16.2
" 22	30	10.7	10.12	1.50	8.62	14.8
" 27	35	11.2	13.30	1.44	11.86	10.9
" 29	37	12	12.70	1.40	11.30	11
May 3	41	12.2	19.10	1.44	17.66	7.5
" 5	43	12.2	19.38	1.44	17.94	7.4
" 12	50	13.5	21.02	1.52	19.50	7.2
	2. Temperature 12°–15° C.					
March 23[1] . . .	—	—	3.98	1.50	2.48	37.5
" 29	6	7	6.66	1.62	5.04	24.3
" 30	7	8	7.06	1.50	5.56	21
April 1	9	10.5	10.49	1.51	8.98	14.3
" 4	12	12.5	18.32	1.46	16.86	8
" 6	14	13.5	22.60	1.30	21.30	5.7
" 8	16	14.5	28.18	1.78	26.40	6
" 12	20	16	36.30	1.70	34.60	4.7
" 16	24	16.5	37.96	1.82	36.14	4.7
" 20	28	17	39.82	1.98	37.84	4.4
" 22	30	17	33.50	1.76	31.74	5.2
	3. Temperature 22°–25° C.					
March 23[1] . . .	—	—	3.98	1.50	2.48	37.5
" 25	2	11	5.29	1.30	3.99	24.6
" 29	6	19	18.01	1.18	16.83	6.5
April 1	9	—	24.56	1.25	23.31	5.1
	4. Individuals of Same Spawning taken from 2 (see "March 30" above), and placed in 3, after they had been in Aquarium 7 Days.					
March 30	7	8	7.06	1.50	5.56	21
" 31	8	11	10.28	1.32	8.86	12.8
April 1	9	13	17.10	1.30	15.60	8.8
" 4	12	14	25.23	1.43	24.80	5.7
" 6	14	14.5	35.62	1.42	34.10	4
" 8	16	14.5	36.02	1.41	34.61	3.9
" 12	20	14.5	32.16	1.35	30.81	4.2

[1] Weight of embryo free of albumen, at beginning of experiment, several days before hatching.

4. The measurements taken were: (1) maximum length, (2) total weight when freed of superficial water, and (3) dry weight, obtained by desiccating the animals in an air-tight chamber containing sulphuric acid until they ceased to lose

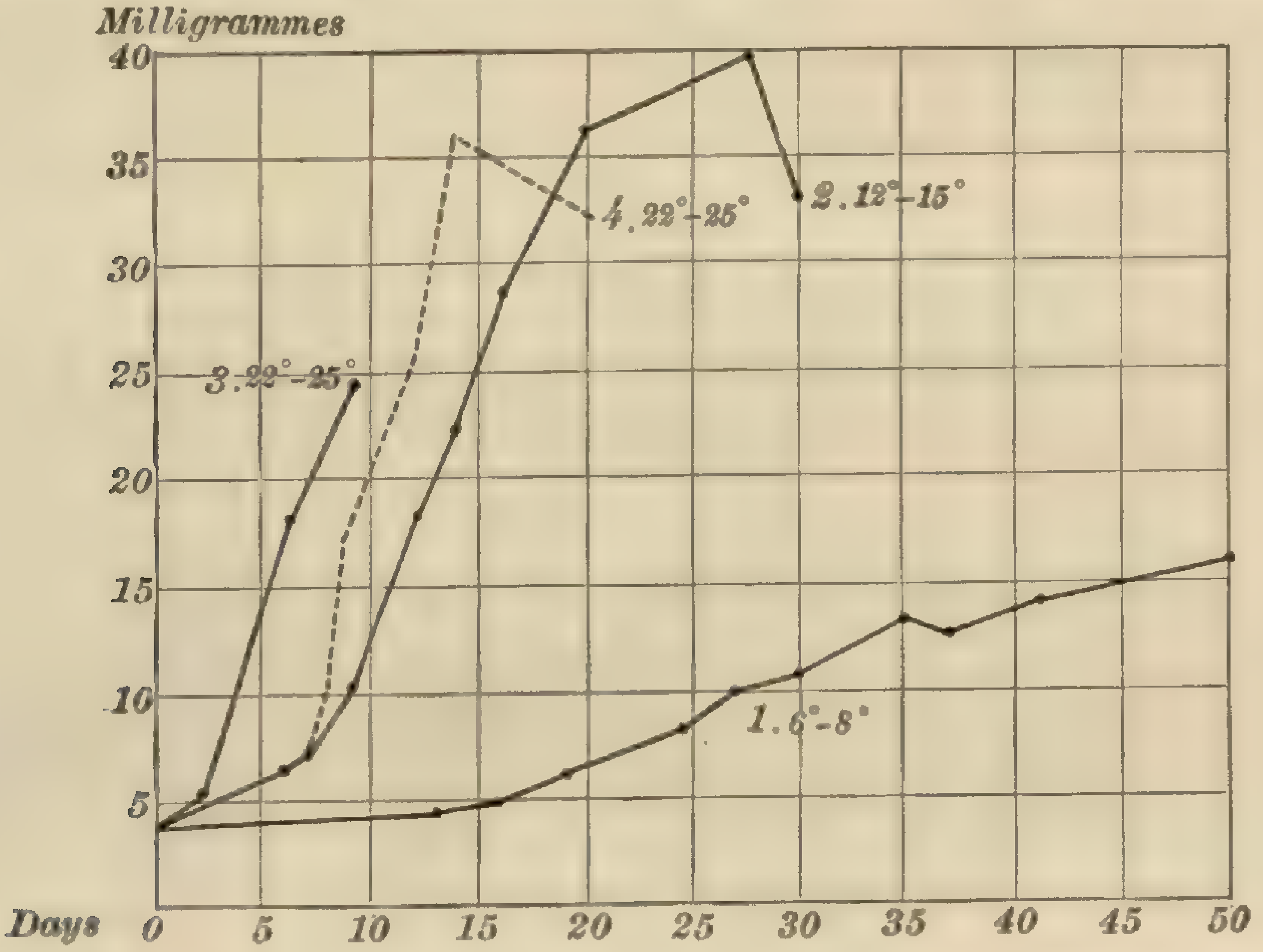

FIG. 1. — Rana. Graphic representation of Table I, column 4, showing average total weight on successive days of the experiment.

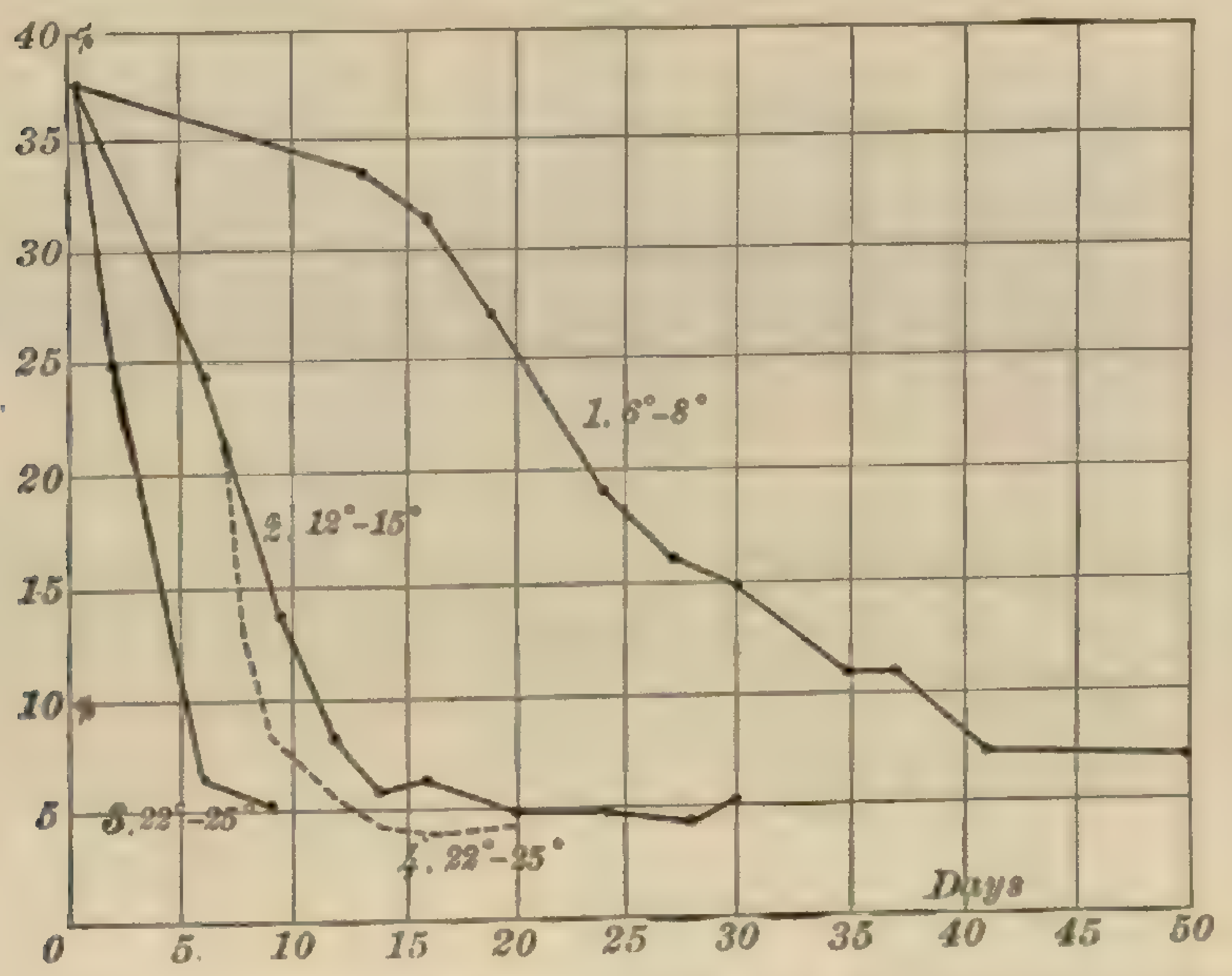

FIG. 2. — Rana. Graphic representation of the ratio of dry substance to the total weight. (See Table I, column 7.)

weight. From these were derived the amount of water present and the percentage of dry substance.

5. *Five* individuals were taken at random in determining all the averages recorded in this paper, except in the later

TABLE II. — AMBLYSTOMA PUNCTATUM.

Date.	No. of Days.	Length. mm.	Average Weight. mg.	Av. Wt. Dry Substance. mg.	Average Weight Water. mg.	Per cent Dry Substance.
1. Temperature 6°–8° C.						
April 12	—	—	—	—	—	—
" 22	10	7.5	6.82	3.02	3.80	44.2
" 27	15	8.5	8.62	2.92	5.70	33.8
May 7	25	10	9.54	2.58	6.95	27
" 17	35	12	13.70	2.70	11.00	19.7
" 24	42	13	16.22	2.70	13.52	16.6
" 26	44	13.5	17.46	2.68	14.58	15.3
June 2	51	14	19.20	2.66	16.54	13.8
" 6	55	14.5	23.80	2.64	21.16	11.1
" 10	59	15	25.82	2.46	23.36	9.5
" 20	69	16	29.64	2.24	27.40	7.5
2. Temperature 12°–18° C.						
April 12	—	—	—	—	—	—
" 20	8	9	9.94	2.90	7.04	29.1
" 27	15	12	12.26	2.74	9.52	22.3
" 29	17	13	15.00	2.84	12.16	18.9
May 3	21	14	18.52	2.64	15.88	14.2
" 7	25	15	22.92	1.88	21.04	8.2
" 17	35	16.5	28.40	2.32	26.08	8.1
" 20	38	16	24.08	1.88	22.20	7.8
" 24	42	17	26.70	2.02	24.68	7.6
" 28	46	17	23.60	1.50	22.10	6.3
3. Temperature 20°–24° C.						
April 12	—	—	—	—	—	—
" 16	4	8.5	8.79	2.69	6.10	30.6
" 20	8	10.5	9.78	2.68	7.10	27
" 22	10	12	12.20	2.59	9.61	21.2
" 25	13	14	14.64	2.78	11.86	19
" 29	17	14	21.84	2.58	19.26	11.8
May 3	21	14.7	23.94	2.22	21.72	9.2
" 7	25	15	22.78	2.54	20.24	11.1
" 16[1]	34	14.5	17.80	1.86	15.94	10.4
" 20[1]	38	14.5	17.00	1.20	15.80	7

[1] Good many dying; evidently not thriving.

measurements of Bufo at the highest temperature; in this latter case *three* were taken.

Results. — The results are embodied in the accompanying tables and in the curves (Figs. 1–6) constructed from them.

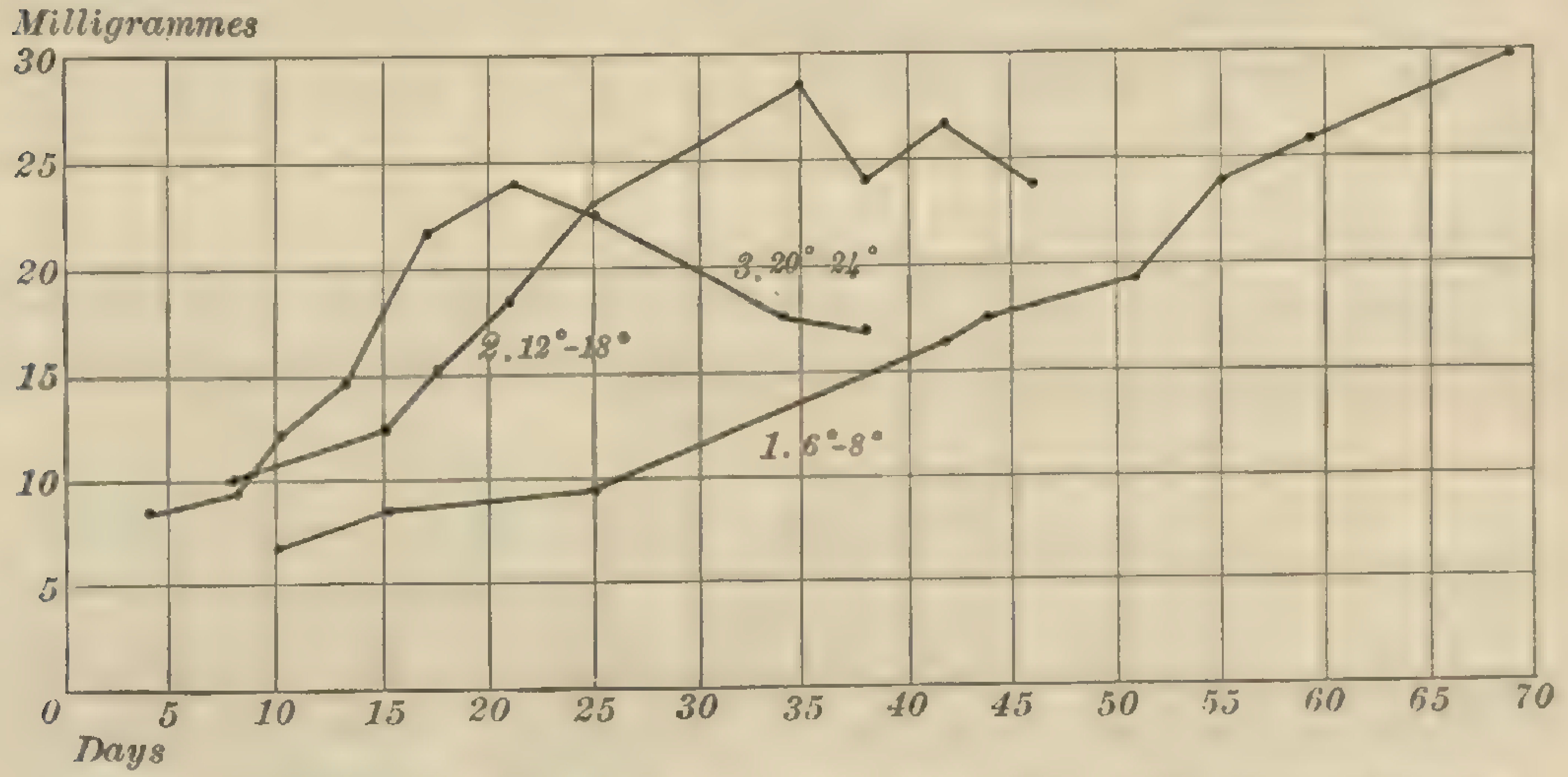

FIG. 3. — Amblystoma. Graphic representation of Table II, column 4, showing average total weight on successive days of the experiment.

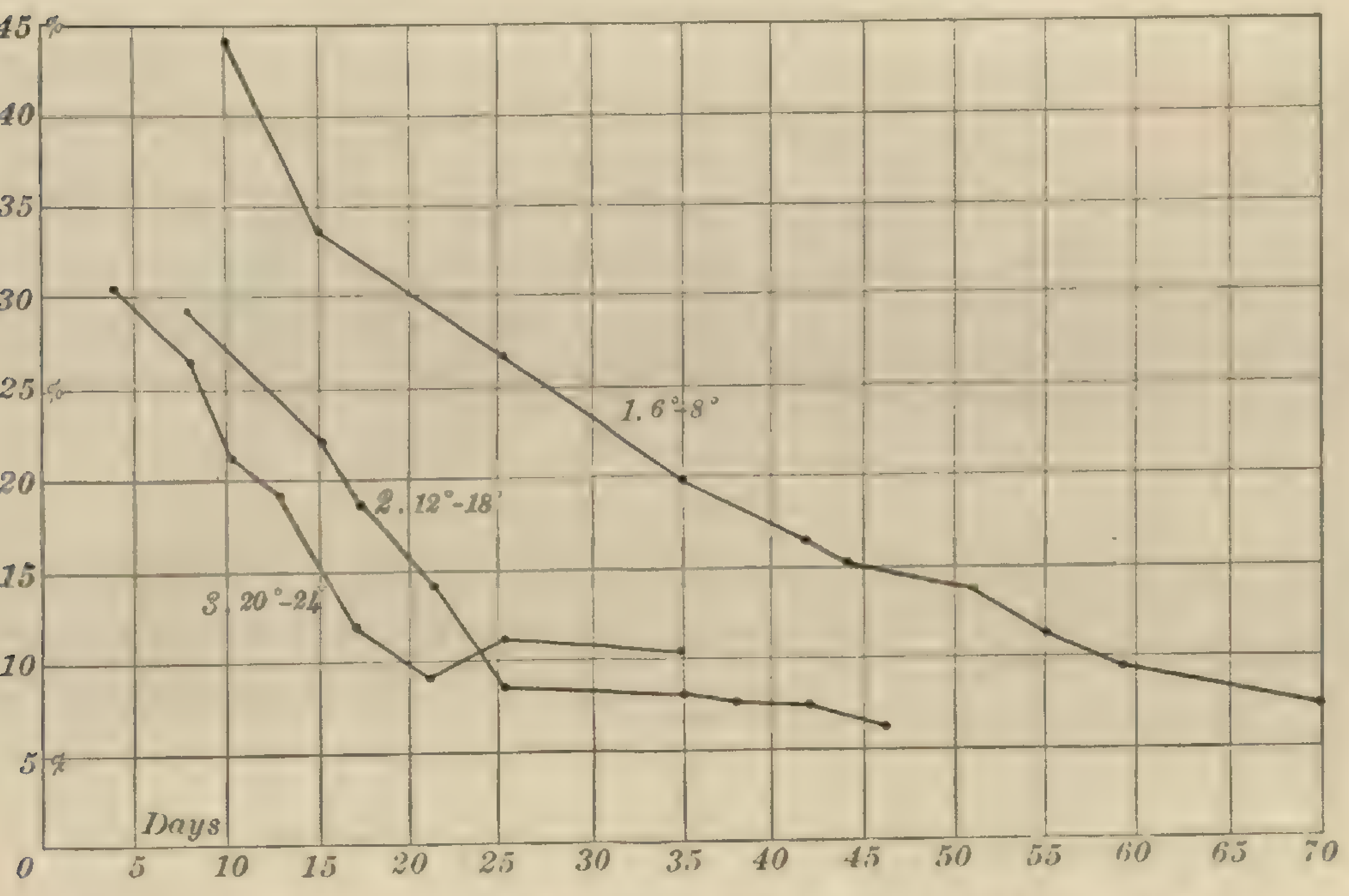

FIG. 4. — Amblystoma. Graphic representation of the ratio of dry substance to the total weight. (See Table II, column 7.)

The column headed "No. of Days" indicates the number of days reckoned from the beginning of the experiment, — not from hatching. The exact date of fertilization is unknown.

In Table I it will be seen that there are two sets of observations

recorded for the highest temperature. Owing to great acceleration and high rate of mortality, the first series (I; 3) was very short. To supplement this record I took some embryos of the same spawning, which had been for seven days in the aquarium, at a temperature of 12°–15° C., and placed them in the warm chamber (I; 4).

An accident prevented my getting a record for Bufo at the lowest temperature (6°–8° C.).

Conclusions. — 1. All the processes involved in the early development of these larvæ are accelerated by an increase of

TABLE III. — BUFO AMERICANUS.

Date.	No. of Days.	Length. mm.	Average Weight. mg.	Av. Wt. Dry Substance. mg.	Average Weight Water. mg.	Per cent Dry Substance.
	1. Temperature 12°–18° C.					
April 26	—	—	—	—	—	—
May 3	7	4.8	3.00	.82	2.18	27.3
" 5	9	6	3.36	1.02	2.34	30
" 7	11	7.5	5.98	.98	5.00	16.3
" 17	21	10.5	12.68	.84	11.84	6.6
" 20	24	10.5	11.00	.70	10.30	6.4
" 24	28	10.8	12.00	.64	11.36	5.3
" 28	32	10.5	12.08	.51	11.57	4.2
" 31	35	10.5	11.62	.60	11.02	5.1
	2. Temperature 22°–25° C.					
April 26	—	—	—	—	—	—
" 30	4	5	2.50	.86	1.64	34.4
May 2	6	8	4.40	.94	3.46	21.4
" 3	7	10	9.54	1.10	8.44	11.5
" 5	9	11	15.96	1.00	14.96	6.6
" 7	11	13	21.00	.96	20.04	4.6
" 9	13	13	21.44	.92	20.52	4.3
" 10	14	13	22.12	.90	21.32	4
" 17	21	13	20.82	1.01	19.81	4.8

temperature within the limits used: + 6° to + 25° C. This is true of the early cell divisions preliminary to hatching, as

well as of the beginning and ending of the period of rapid imbibition of water.

2. Under the conditions of the experiment, the absolute dry weight appears to undergo little change. There is apparently a slight loss from the beginning of the experiment to the period of maximum percentage of water in the embryo. In studying the data I do not find any constant relation between this decrement and the temperature. Inasmuch as the prevailing difference in dry weight is so slight, it seems probable that the sudden fluctuations of weight seen in some of the measurements may be due partly to individual variation in the amount of food taken and in the presence of fæcal matter in the digestive tract, and partly to errors in weighing, which may amount to as much as 0.5 milligram. In some of the smaller weighings this would mean a possible error of 20%. Of course the *probable* error is much less than this. It appears safe to say that during the period embraced in my experiments, — from hatching until the attainment of the maximum percentage of water, — the dry weight is *unaffected* by temperature. It follows, therefore, that the acceleration and retardation experienced at this period in the growth of the larvæ by reason of different temperature conditions is due almost entirely to the changed rate of imbibition of water.

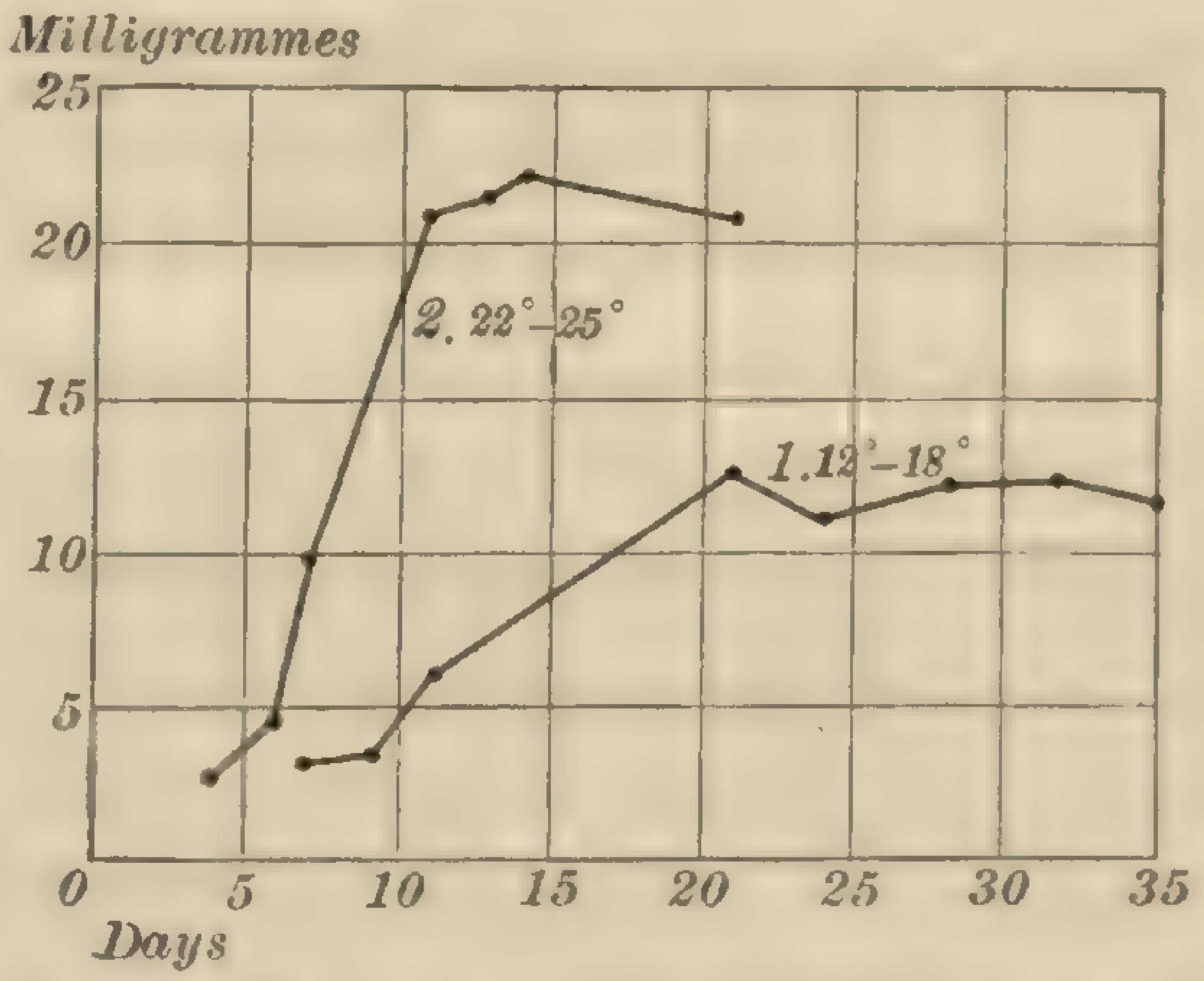

FIG. 5. — Bufo. Graphic representation of Table III, column 4, showing average total weight on successive days of experiment.

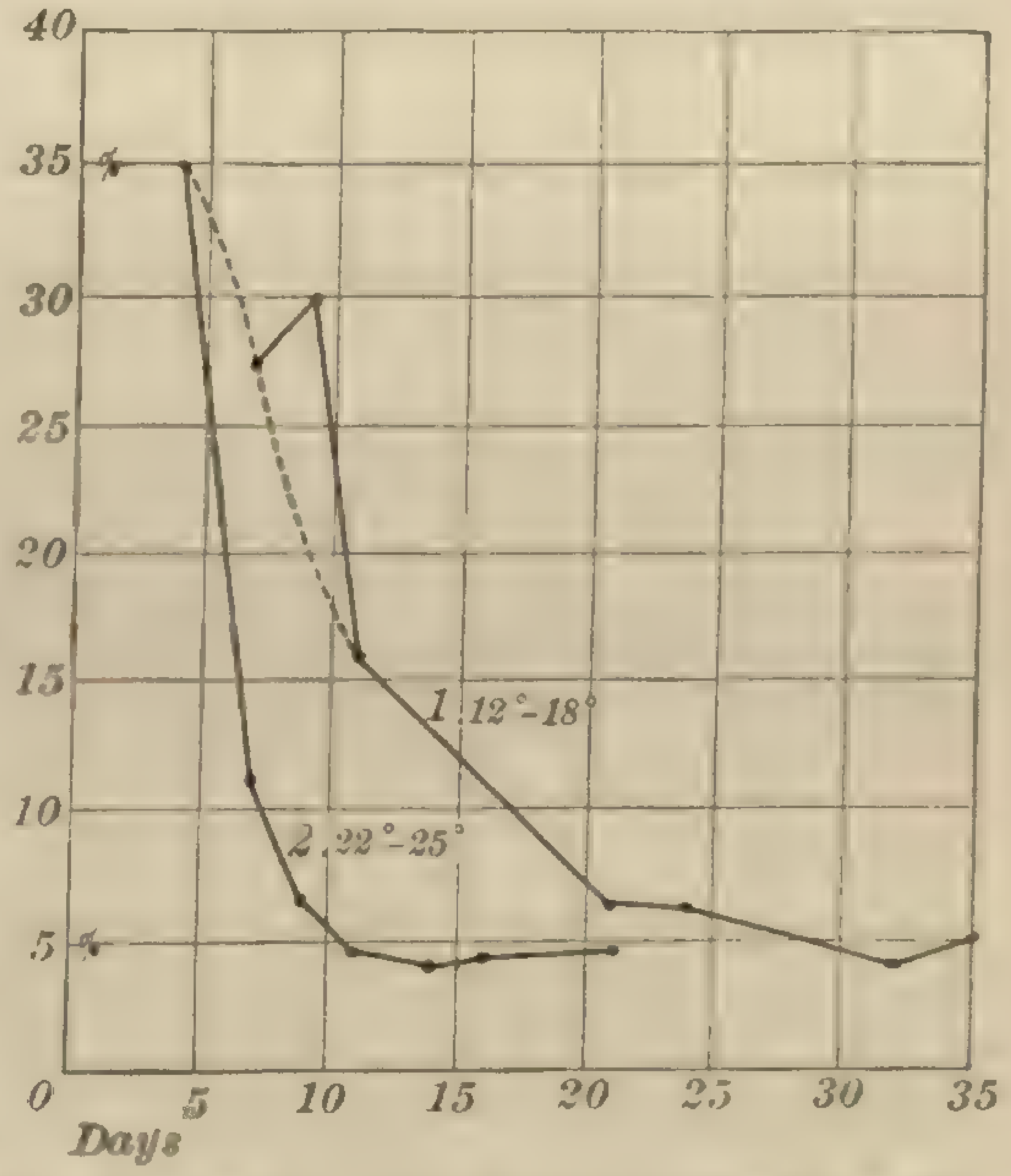

FIG. 6. — Bufo. Graphic representation of the ratio of dry substance to the total weight. (See Table III, column 7.) The broken line indicates the probable position of the curve; the second measurement is doubtless inaccurate.

3. The measurements of Rana also show that there was no appreciable gain in the dry weight of the egg, with the albumen removed, *up to the time of hatching*. There was during the same time a slight increase of water. Thus it appears that a part of the acceleration — by increased temperature — of the cell multiplications leading up to hatching may be due to the earlier inauguration of the imbibitory process.

4. The developmental process up to the point where the water amounts to 75% of the whole weight is not retarded so much by lowered temperature as is the stage representing the *maximum* percentage of water (see Table IV). In the first stage assimilation of yolk and cell division is prominent; in the latter imbibition of water is the main process. The

TABLE IV. — DESIGNED TO SHOW RELATIVE RETARDATION OF AN EARLY AND A LATER EVENT IN THE LARVAL DEVELOPMENT, PRODUCED BY LOWER TEMPERATURES.

	1. TIME IN DAYS REQUIRED TO ATTAIN 75% OF WATER; *i.e.*, 25% DRY SUBSTANCE.			2. TIME IN DAYS REQUIRED TO ATTAIN MAXIMUM PERCENTAGE OF WATER.		
	Highest Temperature.	*Medium Temperature.*	*Lowest Temperature.*	*Highest Temperature.*	*Medium Temperature.*	*Lowest Temperature.*
Rana	2	5.7	20	5	28	50 +
Amblystoma	9	12	27	21	50 +	70 +
Bufo	5.5	7.5	—	14	32	—
Average	5.5	8.4	23.5	13.3	36.6	60 + [1]
Retardation in days, reckoned from time required by highest temperature	—	2.9	18	—	23.3	46.6 +
Retardation in per cent	—	53%	327%	—	175%	350% [1]

[1] This result is certainly too small, since the length of time consumed in my observations did not suffice to reach the minimum percentage of dry substance in the lowest temperature conditions.

conclusion reached above (2), *viz.*, that it is chiefly the imbibitory process which is accelerated by heat, is thus further strengthened.

5. Organisms reared in the warmer conditions tend to attain a maximum percentage of water *slightly higher* than that reached by those reared at a lower temperature. This fact accentuates the conclusion reached in 4, in that a shorter time is required to accomplish a greater result.

6. On the other hand, it appears (see Figs. 1 and 3) that the lower temperatures allow the attainment of a somewhat greater *maximum total weight*, no extraneous food being supplied. The significance of this is not apparent. It is possibly due to the albuminous food material in the egg envelope being better preserved, and hence more completely available as food after hatching, than at the higher temperatures.

7. Finally, the individuals which were subjected for seven days to a temperature of 12°–15° and were then placed in a warm chamber, showed a greater rate of increase of imbibition water than those reared in the warm chamber from the beginning (Figs. 1 and 2). This indicates a tendency compensatory for early unfavorable circumstances, — an instance of the well-known regulative capacity of organisms.

ON THE VARIATION OF THE STATOBLASTS OF PECTINATELLA MAGNIFICA FROM LAKE MICHIGAN, AT CHICAGO.

C. B. DAVENPORT.

THIS study is concerned with the hooks on the statoblasts of one of our common fresh-water Bryozoa — *Pectinatella magnifica* Leidy — taken in August, 1898, from the Jackson Park lagoon, Chicago, connected with Lake Michigan.

Pectinatella is a genus comprising two known species: Magnifica, found in the United States west of the Rocky Mountains, and elsewhere reported only from Hamburg, whither it has doubtless been imported; and Gelatinosa Oka, from Japan.[1] The most striking peculiarity of the genus is the close association of many colonies, which, by secreting together a gelatinous base, come to lie on the surface of a great globular gelatinous mass. One is inclined to think at first that the whole mass must have been produced by the activity of a single colony; but it is certain that it is due to the activity of a number of independent but associated colonies. The separate colonies are, however, probably all derived from a single statoblast, the descendant colony of which has repeatedly divided to produce the colony complex. Consequently, all the associated colonies are closely related; this has an important bearing on our results.

The statoblasts are formed inside of the colonies and frequently in large numbers. In twenty-seven colonies, in which all fully formed statoblasts were counted, the maximum number obtained was forty-six, the minimum was four; and the mode was at twenty to twenty-four. As all colonies contained

[1] A possible third species of this genus has been named by Hyatt (**'66–'68**) *Pectinatella Carteri*, from a single statoblast described by Carter (**'59**), remarkable for its hooks, which grow only at the ends of the statoblast and which are furnished with many lateral claws.

developing, still immature statoblasts, these numbers would have been greater later in the season.

The statoblast consists of a central, nearly circular, disk surrounded by a narrow, ring-shaped float. Placed radially at the margin of the statoblast are a varying number of hooks; the variability of this number was the starting point of the present investigation.

The statoblasts counted were found partly floating free in the preserving fluid and were partly picked out of the colonies, those from one colony being carefully kept together; 827 statoblasts were counted altogether, of which 635 came from known colonies.

Results. — The results of countings made on all statoblasts and on statoblasts from known colonies only is as follows:

Classes.	All Statoblasts.	Statoblasts from Colonies only.	Classes.	All Statoblasts.	Statoblasts from Colonies only.
11	11	7	17	23	18
12	106	79	18	2	1
13	265	201	19	2	2
14	238	186	20	0	0
15	122	93	21	1	1
16	57	47			

The quantitative study of these seriations gives the following constants:

	All Statoblasts.	Statoblasts from Colonies only.
n	827	635
M	13	13
A	$13.782 \pm .031$	$13.814 \pm .036$
ϵ	$1.318 \pm .022$	$1.326 \pm .026$
c	$9.57 \pm .16$	$9.60 \pm .19$
	$F = -1.758$ Type IV Asymmetry $= +0.0766$	

Conclusions. — Since the results based on "all statoblasts" and on "statoblasts from colonies" differ by less than their

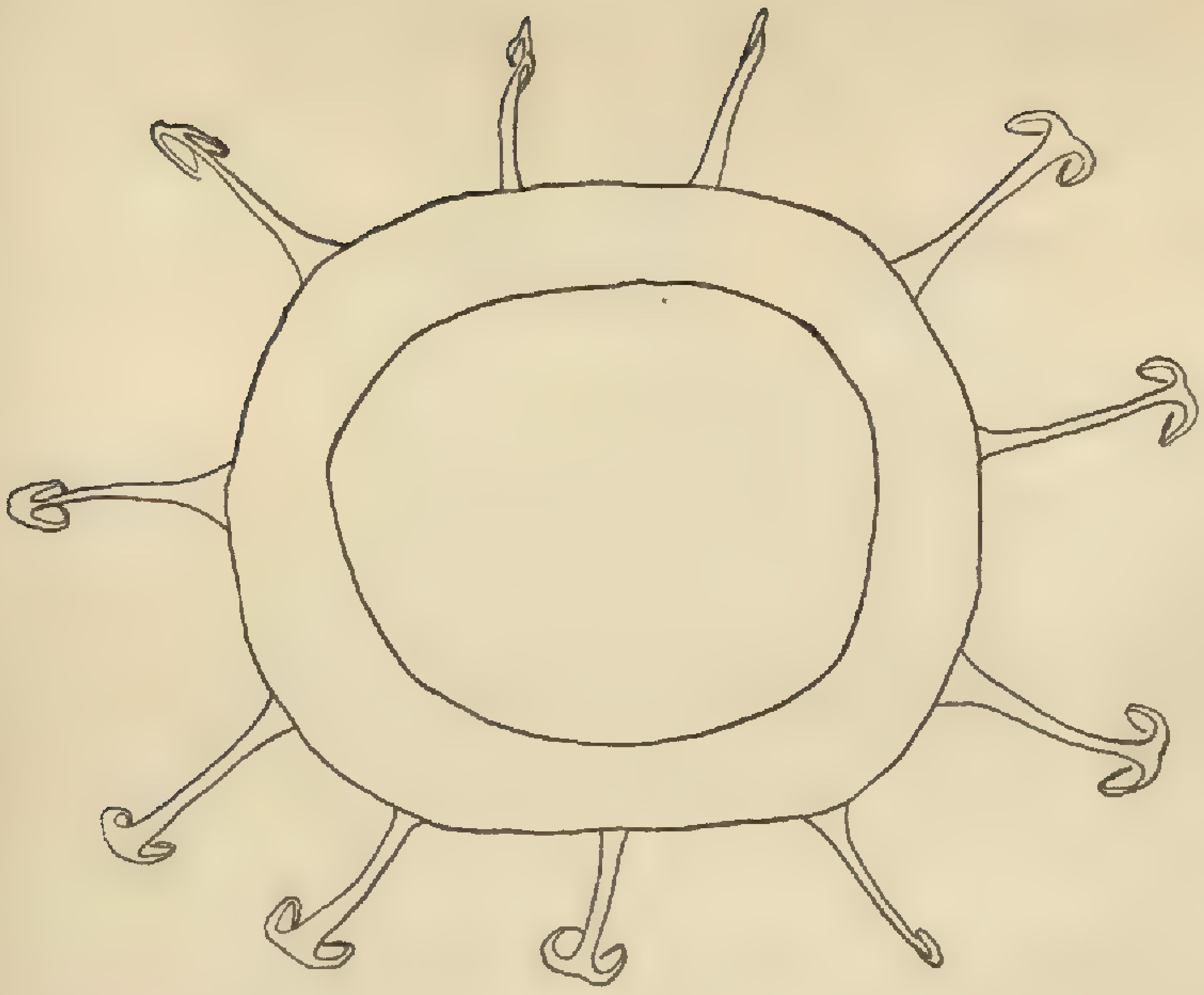

FIG. 1.

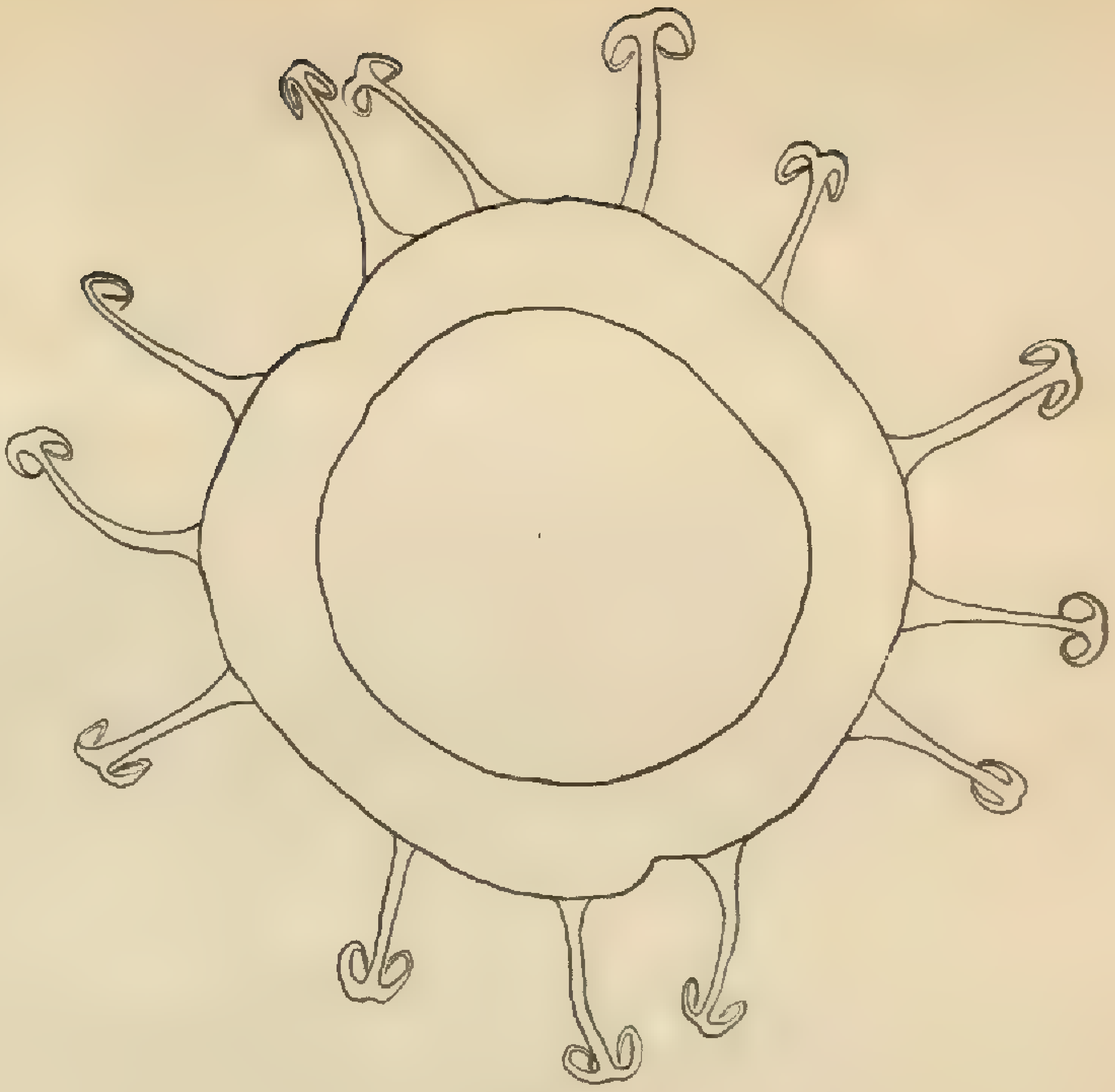

FIG. 2.

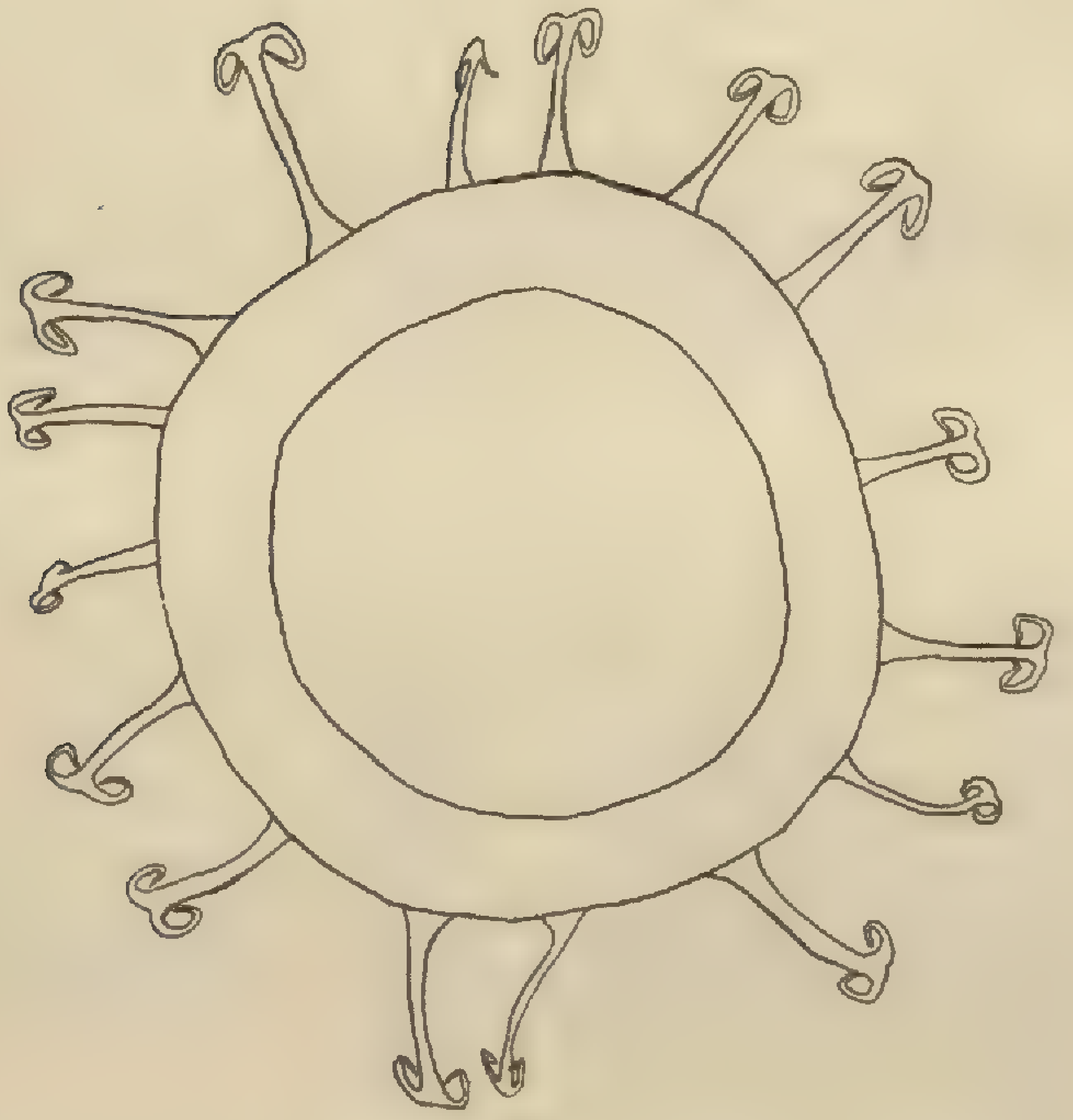

FIG. 3.

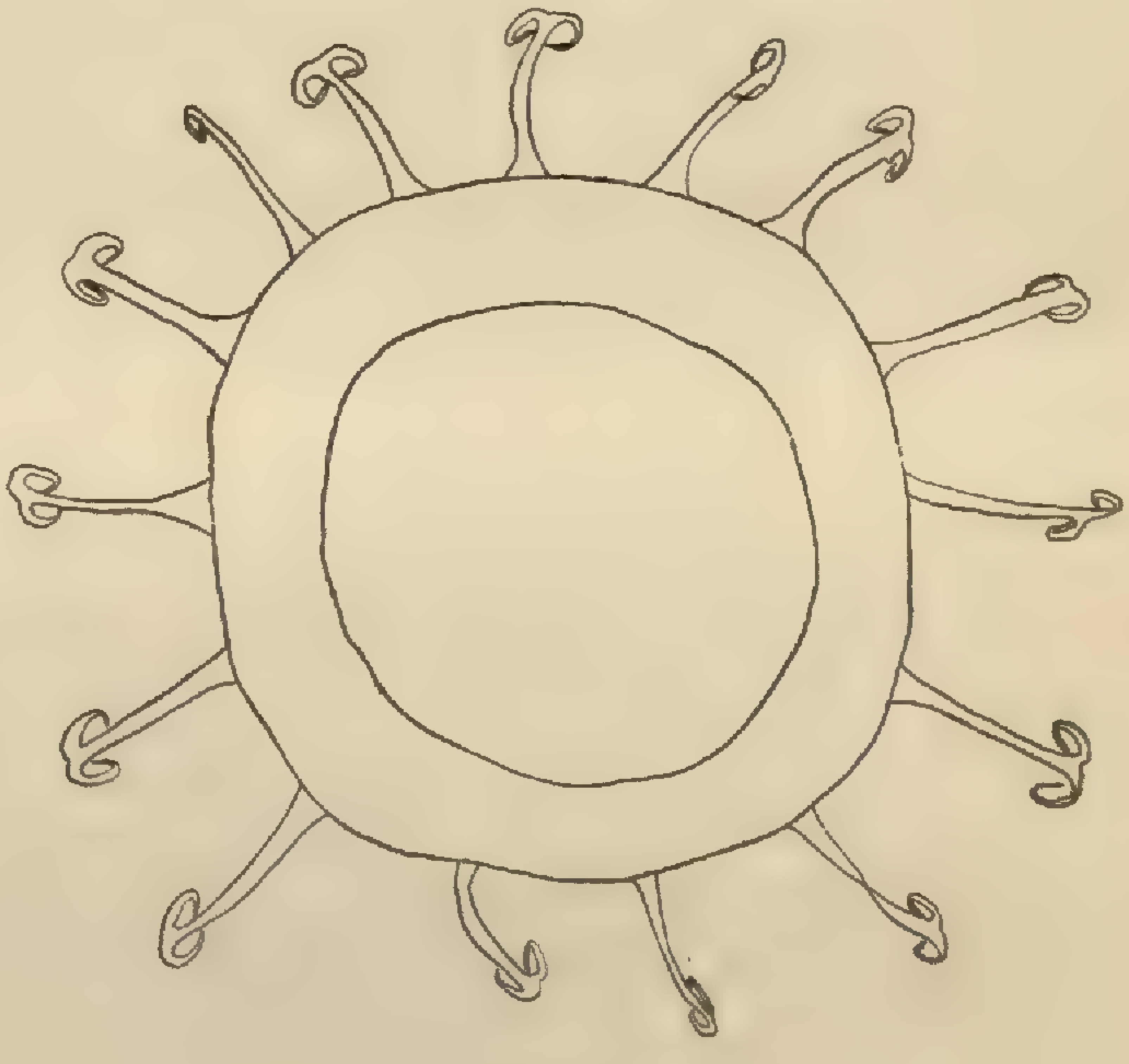

FIG. 4.

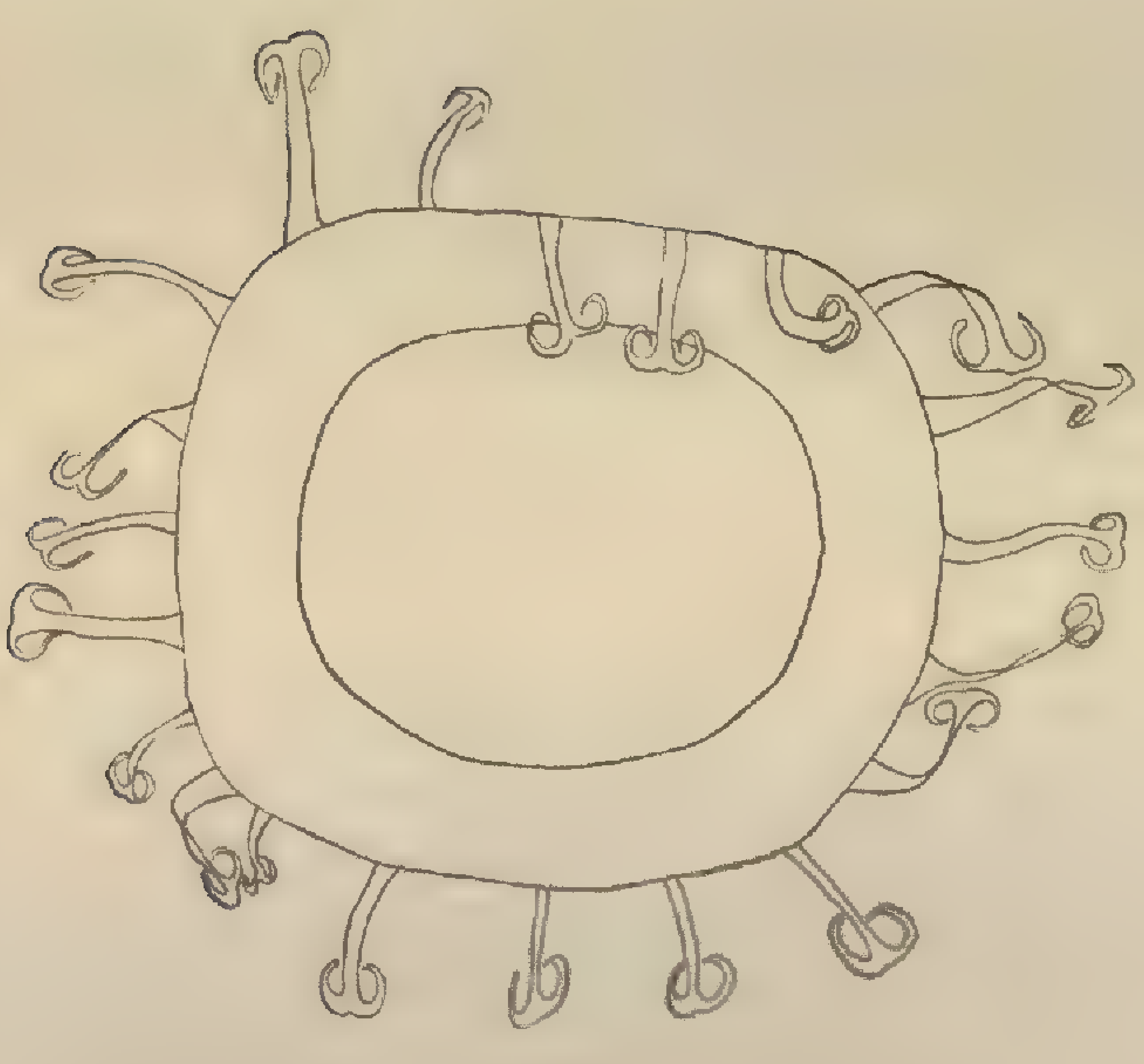

FIG. 5.

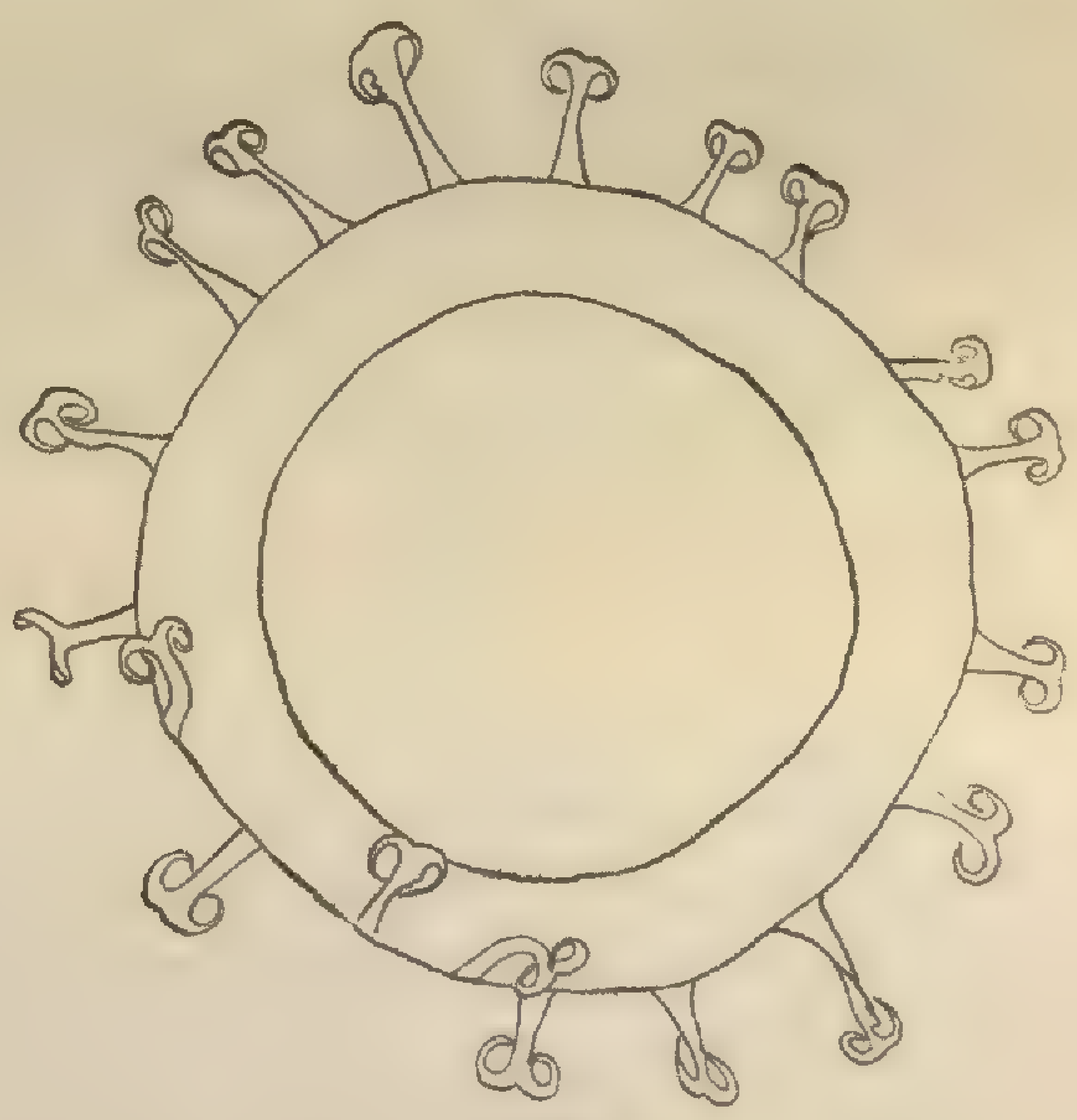

FIG. 6.

FIGS. 1–6. — Outline camera drawings of statoblasts of Pectinatella showing variation in the number of hooks. 1. 11 hooks. 2. 13 hooks. 3. 15 hooks. 4. 16 hooks. 5. 18 hooks. 6. 21 hooks. Compare the length of the hooks in Figs. 1 and 5. × 45.

probable errors, we need discuss only the larger collection of 827 statoblasts.

The mode is 13, the range from 11 to 21; or, omitting the single statoblast with 21 hooks, the range is 11–19 (Figs. 1–6). Statoblasts from Fresh Pond, Cambridge, Mass., are stated by Hyatt to have had, in 1866, 12–17 hooks; and those of Pennissewassee Pond, Maine, 20–22 hooks. The statoblasts of *Pectinatella magnifica* which Kraepelin found at Hamburg varied like those at Fresh Pond, 12–17.

The mode lies over toward the lower limit of the range; consequently the mean lies above the mode and the skewness is rather large, + 0.077.[1] The index of variation (ϵ) is rather large as compared with that of other integral variates. The coefficient of variation (c) is also large as compared with that derived from some graduated variates, as the following series shows:

Organ.	Index of Variation.	Mean.	Coefficient of Variation.
Rays of dorsal fin, Acernia	[2]0.6040	14.16	4.266
Müllerian glands of swine	1.6808	3.50	48.009
Rostral teeth *Palæmonetes varians* . .	0.8627	4.31	19.999
Height of U. S. recruits	2.5848 in.	67.30 in.	8.689
Height of St. Louis schoolgirls, aged 8	5.5524 cm.	118.27 cm.	4.698
Length-breadth index, Bavarian skulls	3.468 mm.	83.07 mm.	8.621
Length right human ♂ femur	23.72 mm.	452.28 mm.	5.425
Length right radius human ♀ radius .	10.95 mm.	214.86 mm.	5.096
Angle of neck of femur with shaft . .	5.578°	124.26°	4.469
Maximum length of clavicle ♀	9.208 mm.	136.85 mm.	6.724
Sacral index ♂	9.353%	115.000%	8.137
Scapular index	3.815%	65.900%	8.575
Infra spinous index of scapula	8.572%	89.454%	9.893

[1] For comparison I introduce some skewness determinations of other qualities:

Pearson, '95,	Weldon's crab measurements, "No. 4" . . .	+ .077
" "	Baxter's height of 25,875 recruits, U. S.	– .038
" "	Porter's height of 2192 St. Louis schoolgirls . .	– .049
" "	900 Bavarian skulls: length-breadth index . . .	+ .032
" "	dorsal teeth of *Palæmonetes varians*	+ .130
Pearson & Filon, '98,	Müllerian glands of swine	+ .311
Rays of Pecten, lower valve	. . . .	+ 0.023
" " " upper "	. . . .	+ 0.0000000058

[2] The first three data are derived from counting. They are integral variates. In them we see that the index of variation is more constant than the coefficient

The curve is of Type IV, or has unlimited range, like most biological curves. The skewness of the distribution indicates possibly a selective weeding out of statoblasts with a small number of hooks. Such a result is not unlikely, for (within certain limits) we might expect statoblasts with a larger number of hooks to have a better chance of keeping their hold and forming new colonies than those with fewer hooks. On the

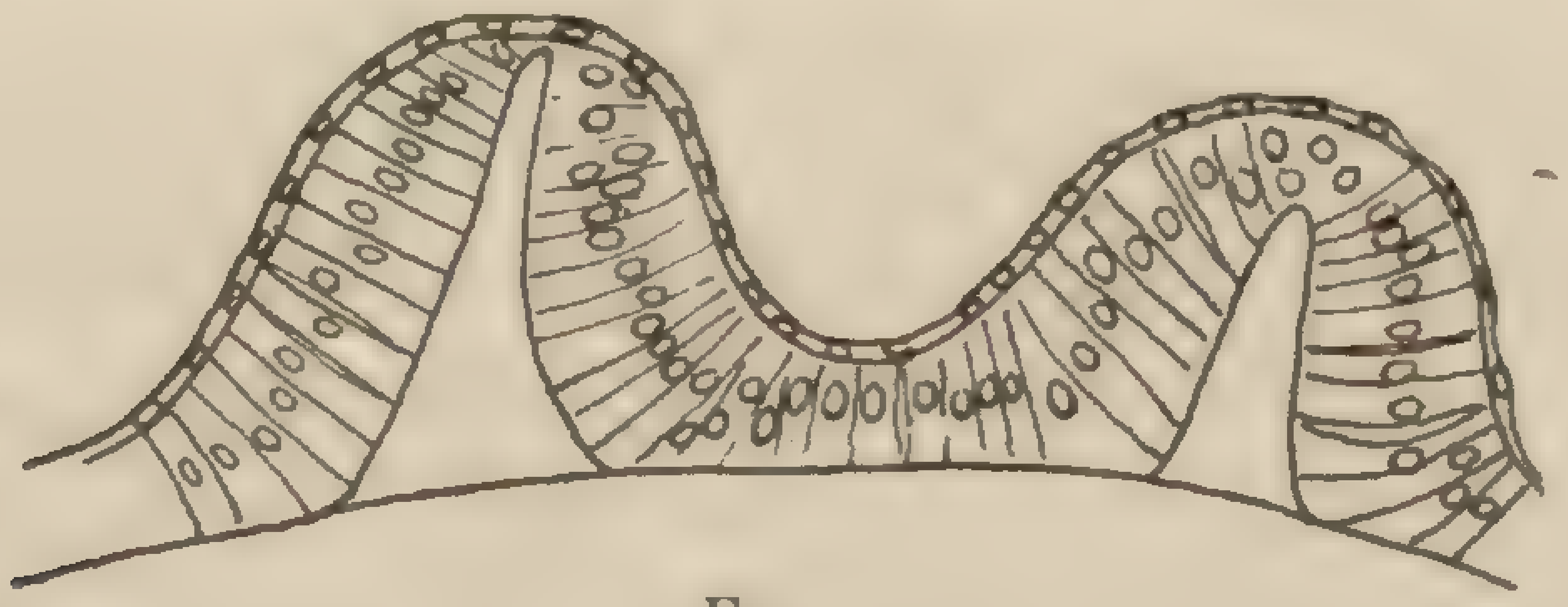

Fig. 7.

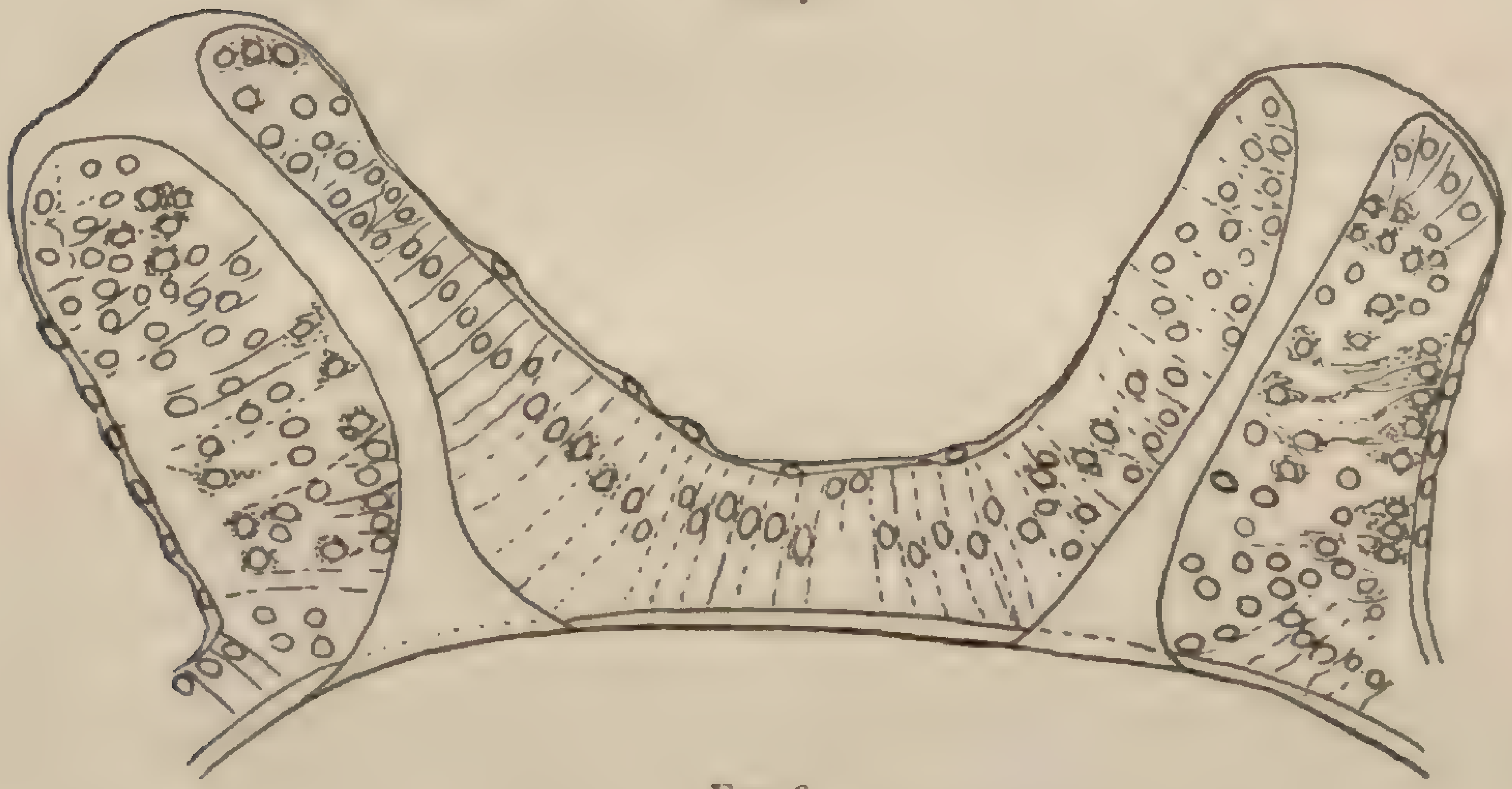

Fig. 8.

Fig. 7. — Early stage in formation of hooks. Section taken in the plane of the float and at its outer margin. ×

Fig. 8. — Later stage in formation of hooks. Section taken as in Fig. 7. × ca. 400.

other hand, the skewness may mean a tendency of the species to give rise to races with a larger modal number of hooks than 13. Such a race has been formed in Maine (Hyatt); and in *P. gelatinosa* the number of hooks is said to be "great" (Oka).

We have next to consider the question whether there is an hereditary tendency to produce a certain constant number of

of variation, and it is doubtless to be preferred to the coefficient. In the remaining cases, which are graduated variates, the coefficients are the more constant, varying from 4 to 9, whereas the indices vary from 2 to 23. Doubtless here the coefficient is to be preferred; moreover it is an abstract number, so that the results are comparable, whether millimeters, inches, degrees, or percentages are employed as units of measurement.

hooks in the same colony; or, in other words, whether the variability in the number of hooks found on statoblasts of the same colony will be less than the variability of the statoblasts from all the colonies taken together. To answer this question, I selected the eleven colonies showing the greatest number of statoblasts, and determined for each colony the ϵ and the c. Then I averaged the ϵ's and the c's for the eleven colonies, and compared these averages with the ϵ and the c of the 635 statoblasts coming from known colonies considered together. If the average ϵ or c of statoblasts from the same colony is no less than the ϵ or c of the population at large, there is no heredity. If, on the other hand, the ϵ's and c's of the colonies average zero, so that the differences between the variability inside the colony and in the whole population is the greatest possible, then there is the strongest possible heredity. In general, the percentage which the difference between the averaged ϵ or c is of the ϵ or c of the whole population, subtracted from unity, will serve as an index of heredity. I find:

	ϵ	c
Average for 11 colonies,	1.197	8.772
All statoblasts from colonies,	1.326	9.597

Index of relative heredity based on ϵ, $1 - \frac{1.197}{1.326} = 1 - 0.9027 = .0973.$

" " " " " " c, $1 - \frac{8.772}{9.597} = 1 - .9140 = .0860.$

The hereditary tendencies inside the colony are thus seen not to be very strong when compared with the tendency to similarity between all the statoblasts of the complex of colonies. I interpret this to mean that there is a close relationship between all the colonies in the complex.

The question next arose, what is the ontogenetic explanation of this variation?

To get some light on this matter, I studied the method of development of the hooks. As already stated, the hooks arise at or near the outer margin of the ring-shaped float; there is a little variation in the line of origin. Even after the float has been formed, the statoblast is clad externally with cells. Those at the outer edge of the statoblast are narrow and elongated

perpendicularly to the surface of the statoblast. Between the cells are large water spaces, which may indicate that the hook-forming layer is turgescent, at least at the time of forming hooks.

The first step in the formation of a hook is a fold (Fig. 7). As many folds arise at about the same time as there are hooks. Consequently the number of hooks is determined by the number of folds, and the question of the cause of variability is transferred to the folds. I had thought at first that each fold might be derived from one cell, but since the hook-forming layer spreads over the forming float and consists already of numerous columnar cells, it would be difficult, if not impossible, to demonstrate this if it were so. The forming papilla is made up of 100 to 200 cells at its beginning. In its center is a core, filled with a secretion, which hardens to form the shaft of the hook. The prongs are secreted as a superficial cuticula at the apex of the papilla (Fig. 8). From this it will be seen that my hypothesis was incorrect, and I find in the embryology no ground for referring the number of hooks to a predetermining number of hook-forming Anlagen.

It is possible that the number of papillæ may be correlated with a variation in the perimeter of the statoblast, so that the number of hooks per unit of perimeter is constant. To settle this question, I measured the perimeter[1] of 125 statoblasts. I found these measurements interesting in themselves. The modal perimeter of the statoblasts was about 3.3 mm. The average was 3.319 ; $\sigma = .06649$ mm. ; and $c = 2.00$, a remarkably low variability, almost one-fifth that of the number of hooks. By the use of the Galton-Pearson-Duncker[2] method of calculating

[1] The perimeter was measured by finding the length of a camera outline by means of the map-measure described in my *Statistical Methods* (New York, John Wiley & Sons, 1899).

[2] The reviewer of my *Statistical Methods*, in *Nature*, Dec. 14, 1899, says : "On p. 33 we notice a lengthy method, quoted from Duncker, given for reducing the product sum ; this should be replaced by the ordinary straightforward process of reduction to the mean." Although I have been satisfied of the correctness of Duncker's formula, which is got from Pearson's by a process of simplification, I calculated r by Pearson's method. Using logarithms, this took about four hours ; whereas to calculate r by Duncker's method took in this case about twenty minutes. The results differed by .001. The length of Pearson's process is a great obstacle to its use.

correlation, I found the correlation between the number of hooks and the length of the periphery of the statoblast to be $r = -.0920 \pm .0055$, a very low correlation, but slightly negative. I give the correlation surface:

X_2	X_1	11	12	13	14	15	16	17	18	19
255–59.9	1					1				
260–64.9	2				1					
265–69.9	3			3	2	1				
270–74.9	4		5	14	12	7	4			1
275–79.9	5		1	18	6	2	5	1	0	1
280–84.9	6	1	3	15	6	4	3			
285–89.9	7			3	0	0	1			

$$X_1 \begin{cases} A = 13.8264. \\ \epsilon = 1.3403. \end{cases} \qquad X_2 \begin{cases} A = 4.8182. \\ \sigma = 1.0499. \end{cases}$$

The negative correlation between length of periphery and number of hooks signifies that in the long run small statoblasts tend to have slightly more hooks than large statoblasts, a result which we should hardly have anticipated. The result makes it clear that the number of hooks which shall develop is not determined by the space at their command for development. In a statoblast with eleven hooks, these are twice as far apart as in a statoblast with twenty-one hooks. The ontogenetic cause of the variation in number of folds remains thus still undetermined.

Although the *number* of hooks is not directly correlated with the periphery of the statoblast, it is rather strongly correlated with the *length* of the hooks; and the correlation is inverse. This is quite striking from superficial observation. To express the relation in a roughly quantitative way, I measured a representative lot of the hooks on each of ten statoblasts. In eight statoblasts having thirteen or fourteen hooks the average length of the hook was about .22 mm.; in the two with sixteen hooks the average length was .19 mm. The figures of statoblasts accompanying this paper will show that at greater extremes the difference in the hooks is still greater.

As the hooks decrease in size with increase in number, we might expect to find the hooks very small in the statoblasts

with many of them. Such apparently is the case, for Oka states that the numerous hooks of *P. gelatinosa* are "minute," projecting beyond the annulus only 0.02 to 0.03 mm.

In studying the hooks, I came across a number of interesting abnormalities that are, indeed, rather common. As already stated, there are typically two claws at the distal end of the

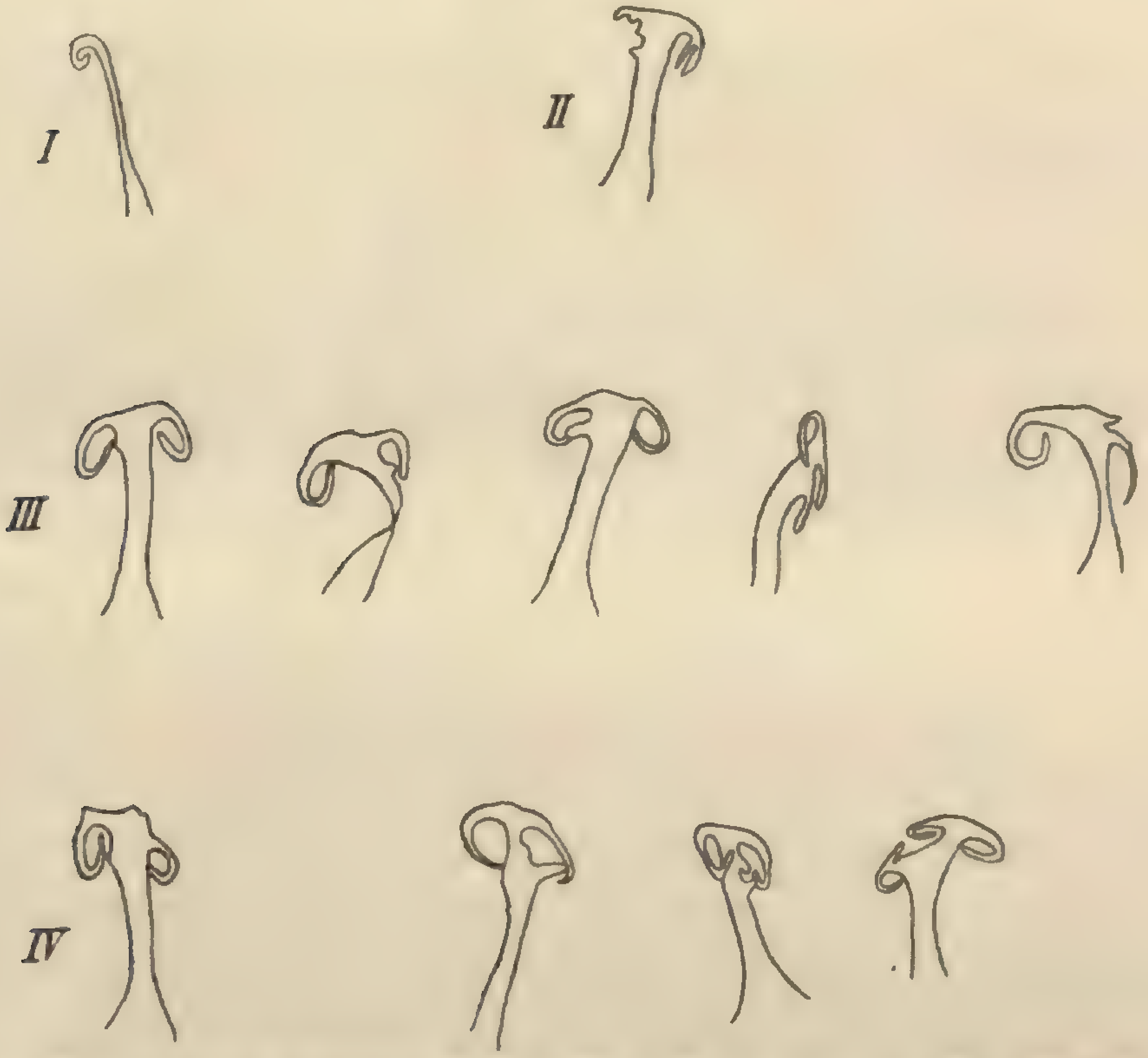

FIG. 9. — Abnormal forms of hooks. *I*, type with only one claw; *II*, type with bifid claw; *III*, type with additional claw on one side, in first four cases below; in last case above, normal; *IV*, type with double outgrowth; in final case a double-headed hook is formed.

hook. The abnormalities concern chiefly these claws. They may be grouped under four types (Fig. 9):

Type I, only one claw.

Type II, a bifid claw.

Type III, an additional claw — on one side.

Type IV, a double outgrowth on one side — producing in extreme cases a hook with two complete double claws at its distal end.

In addition, very rudimentary hooks, mere thread-like spines, are frequently found, often lying outside the typical marginal row. In *P. gelatinosa* these abnormal hooks are apparently even more common. Oka ('90, Pl. XIX, Fig. 35) has figured some of them. They can for the most part be referred to the same

four types. The abnormal multiplication of claws in Pectinatella is paralleled by the normal condition in Cristatella, where the radial outgrowths of the statoblasts form grapnels with many claws. The condition in Cristatella is in so far different as the claws stand out in all radii in Cristatella, whereas they lie almost or wholly in one plane in the case of Pectinatella. Also "*Pectinatella Carteri*" has "many lateral claws" to each hook.

Both abnormalities and individual deviations from mediocrity in Pectinatella are thus normal or modal in other species of Phylactolæmata.

Summary. — The hooks on 827 statoblasts of a Lake Michigan Pectinatella were counted. The number ranged from 11 to 21; the mode was 13; average, 13.782 ± .031; and index of variability, 1.318 ± .022. The skewness was + 0.077; that is, the variation tends in the direction of the larger numbers, and this is correlated with the fact that species or races of Pectinatella with much larger numbers of hooks occur. There is a slight hereditary tendency in the statoblasts from one colony, about 0.1 when 1 is the maximum inheritance. There is an inverse correlation (of − .092 ± .006) between the number of hooks and the perimeter, and a larger one between number and size of hooks. The number of hooks is thus not determined by room, nor does it seem to be predetermined from an early stage of development of the statoblast. The hooks show abnormalities, some of which resemble the normal condition of hooks in Cristatella.

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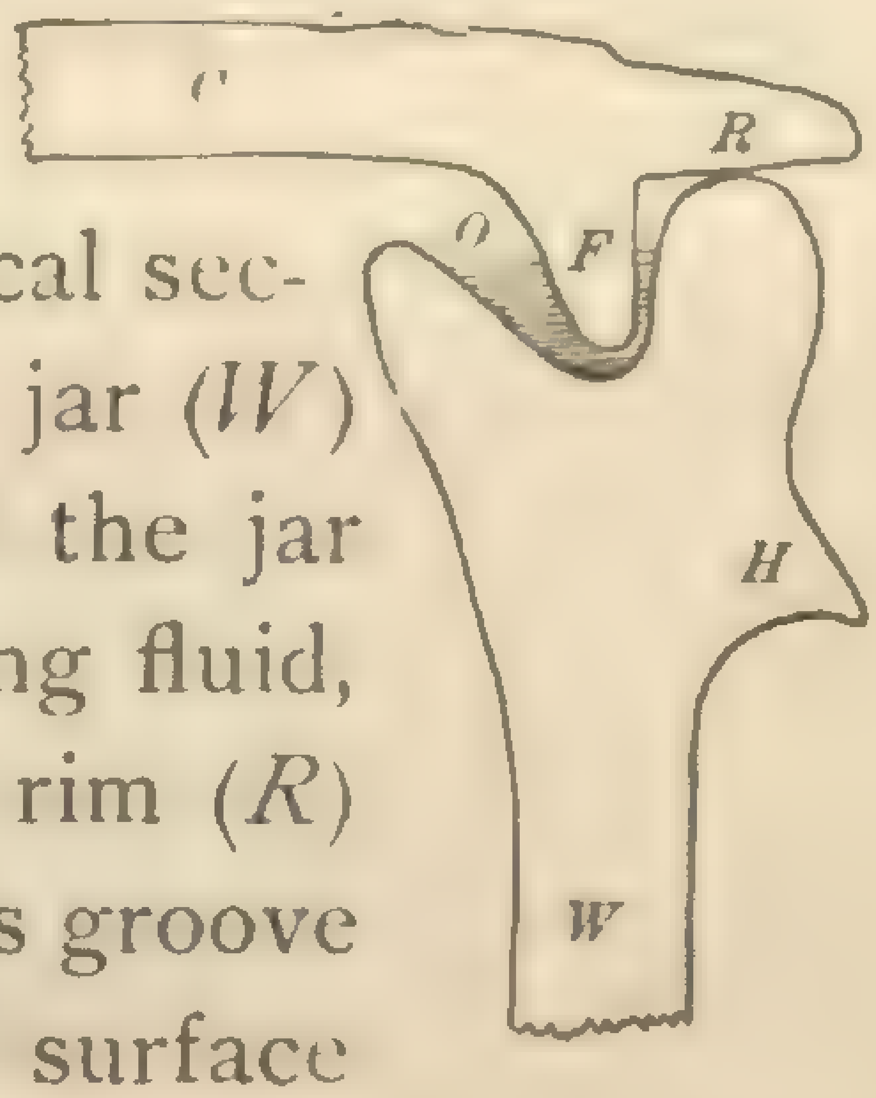
A SEALING STONE JAR FOR ZOÖLOGICAL LABORATORIES.

J. B. JOHNSTON.

THE jar described below was designed as a cheap sealing jar for class use and for the storage of large specimens or of material in quantity for future use. It has been in use since 1898 in three universities in this country, and is now described, since it has proved more satisfactory for the purposes indicated than any other jar known to me. Its cost is inconsiderable when compared with that of glass jars of equal capacity. It has the additional advantages of greater durability and ease of opening and resealing.



The accompanying sketch shows a vertical section of the upper part of the wall of the jar (*W*) and a part of the cover (*C*). The rim of the jar bears a groove (*O*) to be filled with a sealing fluid, indicated by the horizontal shading. The rim (*R*) or edge of the cover projects well beyond this groove to keep out dust. There is upon the under surface of the cover a dependent flange (*F*) fitting into the groove (*O*), so that when the latter is filled with a fluid the jar is sealed. The cover is provided with a knob for lifting, and the rim of the jar, with handles (*H*).

The jars are made by the Zanesville Stoneware Company, Zanesville, Ohio, in the following sizes, inside measurement in inches :

Depth . . .	8	8	12	12	24
Diameter . .	10	12	10	12	12

I have tried a number of sealing fluids before anything suitable for permanent sealing was found. For daily class use it is sufficient to fill the groove with water. Indeed, the mere empty groove reduces the rate of evaporation very considerably, since the alcohol or other vapor must pass downward

to escape beneath the flange. For permanent sealing, glycerine is useless with alcohol, and most available oils "creep" so rapidly that the groove is soon emptied. However, a heavy paraffin oil, obtainable from the Edison Manufacturing Company of New York City, being free from this characteristic, and non-volatile, makes an excellent sealing medium.

West Virginia University, Morgantown,
October 4, 1900.

REVIEWS OF RECENT LITERATURE.

ANTHROPOLOGY.

African Masks and Secret Societies.[1] — The subject is divided ethnographically and ethnologically. That is, the author arranges his material first in geographical order, beginning with South and East Africa and passing through the west coast to the northwest; then upon this material he constructs a historical and racial development in the use and manufacture of masks and in the working of the secret fraternities. For further work the second half, the correctness of the conclusions being assumed, will be the starting point. The introduction to this part presents different analyses of masks and the author's judgments upon these. His conclusion offers some suggestions as to work and methods. The introduction to the second half is in part as follows (p. 157): "Two methods are known of grouping masks in their entirety so as to get a general view of them; either according to their significance or their form. Andree has undertaken the former as follows:

Religious Masks,
War Masks,
Funeral Masks (*Leichenmasken*),
Play and Dance Masks.

This classification has the disadvantage of leaving out of consideration their historical development. Form is not taken into account, and customs are developed like side scenes, without regard to the proper guiding principles of observation. Such a division is more of a benefit to the customs than to the masks when it comes to the determination of the relations between the individual groups. Ratzel has given a classification more appropriate, because less assuming:

A. Simple imitations of the human face.
   1. Rough works.
   2. Careful copies true to nature.
   3. Geometric conventionalizations (*stilisirt*) partly dependent on tattooing.

[1] Frobenius, L. Die Masken und Geheimbünde Afrikas, *Nova Act. Acad. Cæs. Leop.-Carol. Germanicæ. Nat. Cur.*, tome lxxiv (1898), pp. 1–278, Tables I–XIV.

B. Distorted figures, caricatures, scare-faces.

4. Grimaces to arouse mirth or terror; dance or war masks.

C. Animal masks.

D. Head-pieces.

"As may be seen from this arrangement, it deals almost exclusively with the forms from whose nature only occasional conclusions as to their significance can be drawn. Such is an ethnographical view that would be very well in place where geographical relations had been already worked out and where only a collection of the forms of a place, district, or province had to be made. So such tables as Ratzel's are only desirable when convenient to a treating of masks like that of Haddon on those of southeastern New Guinea. For more esoteric work these systems have little value. The method that Dall has used might be considered, and in fact would not be at all bad, if one could convince himself of the truth of his premise, *viz.*, that masks arose from weapons of protection."

Dall's searching classification is then given; it is allowed by the author to be clever, but condemned by the false premise just quoted. Nevertheless, he admits that Dall has shown that the "relations of form and significance, while various, are yet close." The introduction continues: "Every experienced man must have observed from the ethnographic part (of the book) that the African masks compose no simple structure, and that custom and belief are continually influencing the form, changing it and developing it.

"Masks are bound up with particular ceremonies, — they always appear at funeral feasts; where the fraternities begin to disintegrate, masks gain in variety (Cameroon, Loango, Yoruba).

"The classes of head and body masks stand forth clear and distinct: here they are combined, here they are divided. We see derived forms on every hand, as in the bushy circumcision dresses.

"In short, African masks, after examination, attain the appearance of a composite whole, a complicated development, whose several parts are to be traced back to various sources. So it is worth while to note our old point: the form corresponds to the content. Plastic expression, custom, are the forms which owe their existence to the content, to beliefs.

"If we now observe these beliefs and views in origin and growth from their roots up, we shall readily derive the understanding for the various points in our field of study. . . ."

Frobenius then proceeds to derive nearly all African masks and customs from the cult of the dead. Even tree worship arises from

planting a tree on the grave instead of burying the dead in the forest. Hence come sacred posts, stakes, and scepters. Masks refer back to this cult in two ways. First, in some places the dead are buried in peculiar little huts, and hut temples readily arise. An imitation of these "spirit huts" is seen in the tent- or hut-like head coverings, and shoulder- or loin-coverings that form a large chapter in African costumes. It would be hard otherwise to explain the apparent superfluity of clothing in a climate demanding the opposite. The second development is from the human skull: starting from skull dances with the crania tied about the waist, or held whole or in part in the mouth, the transition is easy to skull masks, conventionalized traces of which are to be seen in some of the masks pictured in the text (p. 182).

The work is not too analytic to be interesting; the first part is full of traveler's tales set down by the author (apparently not an African visitor himself) with an Herodotus-like naïveté. The illustrations are numerous and good, but beset with a vicious system of numbering which makes reference a difficult task. There are some misprints in the German, and quite a number in the little English text quoted.

Towards the end the author makes comparisons between the masks and customs of Africa and Oceanica, which prove to him a connection between them, and that the African instances point to more eastern sources.

The conclusion is partly as follows: "It should not be assumed that the subject is exhausted in the present work. Still, no such complete handling has as yet been devoted to the masks of a primitive people. The work may ask for some indulgence from its nature. Whoever wanders in unbeaten paths, as we do here, must often, like the pioneer in his work, find his hand too rough for skilled labor. Therefore many questions are still open and many a fault may have been committed. . . .

"I repeat my often expressed wish to strike out from the scientific order of the day the unhappy nomenclature which so retards progress. Words like 'magician' ('*Zauberer*'), 'fetich,' are essentially superfluous. Their existence naturally gives to the inquirer a false idea of science. He thinks his duty done when he has dubbed an article as of the class of 'fetiches.' I can tell a story about that. I enlightened several missionaries to the effect that by the word 'fetich' absolutely nothing worth while was expressed. These gentlemen thereupon sought for the significance of many of

the amulets of the west coast called 'fetiches.' Behold pages of description and explanation of their use and significance poured in. That was evidence that my desire was justified. . . .

"It seems as if the problem of African philosophy, or, for aught I care, religion, had been so worked over as to be worn out and a bore. Yet the many tomes on fetichism and African religion have brought forth not much more than clever views, — hardly ethnological.

"It now begins to dawn, and the light shows very remarkable and unexpected phenomena. We can only attain clearness if in Africa too inquiry is directed along the new lines. It is an aim of this work to urge on this process. It will be and can be only a pleasure if students and ethnologists tear up the book and discover faults and mistakes; up and forward! The ethnological part will be justified if it only offers inducement to zealous coöperation and energetic progress."

Charles Peabody.

Ancient Crania from the Valley of the Rhone. — Dr. Pittard[1] has published a summary of his investigations upon a large series of ancient Valaisian crania. After an exhaustive comparison of the crania of the two sexes he reaches the following conclusions :

1. In the auricular angles the female skull surpasses the male by the absolute size of the frontal angle, by the size of the two occipital angles — cerebral as well as cerebellar.

2. In the curves the various segments of the skull are larger in the male.

3. The weight of the male skull is absolutely greater, as is also the cranial capacity ; but relatively the female skull has greater capacity in proportion to its weight.

4. In relation to their total horizontal circumference the female skulls have a greater capacity than the male.

5. The principal cerebral diameters are better developed in proportion to the cranial capacity in the female skulls.

6. The frontal breadth is greater relatively to the facial breadth in the females.

7. On the other hand, the parietal region is less developed in the female skull if compared with the horizontal circumference and the true cerebral curve.

8. In the female skull the frontal is more vertical, the nasal aperture is larger, and the orbits higher.

[1] Pittard, Eugène. Quelques Comparaisons Sexuelles du Crânes Anciens de la Vallée du Rhone, *L'Anthropologie*, tome ix, No. 2.

9. It is by the frontal breadth and in a lesser degree by the maximum transverse breadth that the female skull approaches most closely to the male; it is farthest from the male skull in the basal region and in the face; the forehead is larger relatively to the face than among the male skulls.

"In conclusion, the above researches, incomplete as they are, demonstrate that the female skull has, in relation to the male cranium, a frontal type, as has been shown already by M. Manouvrier, and that the cranial capacity is relatively greater." It is to be remembered that these results were obtained from the study of a brachycephalic series of crania.

Notes. — Dr. R. Verneau (*L'Anthropologie*, Tome IX, p. 2) figures and describes a new instrument for measuring cranial angles and diameters. The advantages claimed by the inventor for this new apparatus are that:

1. It renders measurements comparable by always securing the parts in the same relative position.

2. The projections can be quickly measured which heretofore have been obtained by geometric drawings.

3. Both vertical and horizontal projections can be taken at the same time.

4. All the dihedral angles relating to one horizontal plane can be directly measured.

We have received reprints of two papers by Mr. James Mooney of interest to ethnologists and students of American history. "The Cherokee River Cult" was published in the *Journal of American Folklore*, Vol. XIII. The peculiarly sacred character of the flowing stream to the primitive mind is explained, and a number of formulas used by the native priests when invoking the aid of the river-god are translated.

Reprinted from the *American Anthropologist* of July, 1899, is an account of "The End of the Natchez." Mr. Mooney devotes himself especially to the history of the tribe subsequent to the year 1730, when they were broken and dispersed by the French. Perhaps twenty individuals belonging to this tribe survive, all living in the Indian Territory with the Creeks.

In the *Proceedings of the American Antiquarian Society*, Vol. XIII, 1900, is published a paper by Mr. Lucien Carr upon "The Mascoutins." The history and even the identity of this tribe has been

uncertain. Mr. Carr shows that they were a branch of the Shawnee division of the Algonquian stock that was finally absorbed by another branch, the Kickapoos.

F. R.

GENERAL BIOLOGY.

Biology of Crystals.[1] — From biology to the structure of crystals seems a far cry, but those who have penetrated farthest in the study of organisms have time and time again come to the borderland of the inorganic realm. Most have declined to go over into the untraveled domain of a foreign country. Professor Bütschli is not one of these. His studies on the structure of protoplasm are the most profound that have been made. They led him to recognize a single fundamental protoplasmic structure, — the alveolar or "foam" structure, — of which the karyokinetic figures are only special expressions. At the time of his early discoveries there were few inorganic substances which were known to have any such structure. Emulsions alone were comparable. Studies of starch, cellulose, and chitin revealed to Bütschli a similar alveolar structure, and now he has continued his researches into crystals of sulphur and certain salts and finds here the same structure. The protoplasmic structure is, then, not something peculiar to living substance, but is probably characteristic of substance in general — at least of changing, forming, growing substance. Moreover, in the forming crystal we have radial lines proceeding from a center, and these are *structurally* like the radiations of the asters — like, because due in both cases to a central pull exerted on an alveolar structure.

The vast mass of the work deals with matters of interest, first of all, to crystallographers and physical chemists — the microscopic details of crystal formation, the polymorphism in crystallization, the determination of the polymorphic form by external conditions. These are matters which will be eagerly read by the biologist also, a few years hence, when the close and fundamental relations between organic development and crystalline development become more generally appreciated.

C. B. D.

[1] Bütschli, O. *Untersuchungen über Microstrukturen des erstarrten Schwefels, nebst Bemerkungen über Sublimation, Überschmelzung und Übersättigung des Schwefels und einiger anderer Körper.* Leipzig, Engelmann, 1900. Quarto, 96 pp., 4 pls., 6 figs.

Finding Flaws. — Every scientific man knows that science is progressing and ideas are changing. Aristotle's writings on animals read strangely to-day, but we are not therefore to lay stress on his limitations. Darwin wrote the first edition of the *Origin of Species* over forty years ago, and it would be strange indeed if every part of it were acceptable to-day. Every bit of Darwin's earlier evolutionary writings was not acceptable to Darwin himself before he died — a fact to be put down to his credit. The author of this book[1] devotes over three hundred pages to pointing out Darwin's changes of views, "special errors and inconsistencies," "looseness and contradictions." Some of the "flaws" which the author holds up to view and takes great delight in pointing to again and again belong to the category of natural advances in knowledge; others are still debatable points; in other cases the author seems to be straining things to make a point. The worst of it is that the whole book is written in a style of oiled fluency, cocksureness, and conceit, which makes the reader doubt the author's sincerity. Thus on page 193:

> I have tried to understand many things, but Mr. Darwin I cannot understand. You cannot have "uniformity of conditions" and uniformitarianism of process and result too; for the one is based on fixity and the other on fluctuation — it may be slow, but ceaseless — though it may be very, very slow, yet also of a necessity very, very sure. Hegel's Absolute was always a becoming; phenomena, conditions, are always a-coming and a-going; it is because of this that they are phenomena and conditions, and to have to write thus in the year of grace 1899, in reference to the work not only of a great naturalist but of a thinker, makes me rather ashamed of falling back so much and so fully on what I was well taught in the logic and metaphysic class-room of Edinburgh University by the worthy successor of Sir William Hamilton, "forty years ago, my boys, forty years ago."

But after all, if only one can be undisturbed by these personal things, he will find in the book many interesting facts which the author has collected and which are new to speculative books of this sort.

Recent Work in Electrotaxis. — In two papers[2] published within the year, Dr. Oskar Carlgren has considerably advanced our

[1] Alexander, P. V. *Darwin and Darwinism, Pure and Mixed.* A Criticism, with Some Suggestions. London, John Bole, Sons, and Danielson, 1899. 346 pp.

[2] Carlgren, O. Ueber die Einwirkung des constanten galvanischen Stromes auf niedere Organismen, *Arch. Anat. u. Physiol.*, Physiol. Abth., 1900, pp. 49–76.

Carlgren, O. Ueber die Einwirkung u. s. w.: Zweite Mittheilung: Versuche an verschiedenen Entwicklungsstadien einiger Evertebraten, *Arch. Anat. u. Physiol.*, Physiol. Abth., 1900, pp. 465–480.

knowledge in regard to the action of the constant electric current on lower organisms. The work bears evidence of having been carefully and well done. The first of the two papers is principally given to a description of the electrotactic reactions of Volvox, introduced by a brief account of the normal movements of the animals based largely on the results of Klein and Rösel. He finds the sense of the response to the current to be kathodic immediately after the circuit is completed. After the current has been passing for some time, however, this kathodic response becomes less and less evident, until finally there ensues a more or less distinct anodic movement; but this latter never becomes so well marked as the previous motion towards the kathode. If the Volvox is placed in a thin gelatine solution, so that it remains alive but is unable to move, very striking changes in the form of the body accompany the action of the current. The anode side of the colony becomes wrinkled and crumpled together, while the kathode side is correspondingly swollen out. These phenomena become more apparent the longer the current acts, and take place without relation to the orientation of the axis of the body with reference to the current direction. At the same time all the parthenogonidia move towards the anode side of the colony. This movement is evidently an entirely passive one, since it occurs regularly in all stages of their development, as well before they are able to move actively as after. That the change in body form is of a purely passive character is evidenced by the fact that it takes place in the same way in colonies which have been killed in formalin. To extend the results the effect of the current was tried on lifeless individuals of *Paramecium aurelia* and *bursaria*, *Colpidium colpoda*, and Amœbæ of different species, and in all these cases there resulted the anode crumpling and the kathode swelling. In his theoretical discussion Carlgren advances the view that the effect of the current on organisms is to a certain extent of a purely physical nature. He believes that this physical action is of extreme importance, but does not attempt to make it account for all the facts. His results make it evident that in any future work on the subject this factor must at least be considered.

In the second paper there is a detailed account of the electrotactic response of the larvæ and embryos of a number of marine invertebrates. The point of greatest general interest is in regard to the reactions of the larvæ of certain echinoderms (*Strongylocentrotus lividus*, *Sphærechinus granularis*, *Ophiotrix fragilis*, and *Asteracanthion glacialis*). Young free-swimming stages of these animals gave

no response whatever. Older larvæ, Plutei and Bipennariæ, became oriented in stronger currents and went to the kathode. Again at a later stage of development the electrotaxis completely disappears. All theoretical discussion of the results is left for a future paper.

In view of the character of the papers here reviewed, particularly the first, further work along the same lines by Dr. Carlgren will be awaited with interest.

RAYMOND PEARL.

ZOÖLOGY.

An Introduction to Zoölogy.[1] — In twenty chapters the authors take up successively the grasshopper, the butterfly, the beetle, the fly, the lithobius, the spider, the crayfish, daphnia, the earthworm, nereis, the slug, the fresh-water clam, the starfish, the hydra, paramœcium, the smelt, the newt, the lizard, the English sparrow, the mouse. In each the type and "its allies" are described from a general natural-history standpoint and with an appended key to the chief representatives of the group. A last chapter deals briefly with the development of the frog's egg.

Then in one appendix we find the stimulating outlines of laboratory work upon each of the above twenty-one forms that was proposed for entrance requirement at the Lawrence Scientific School, Harvard University. A second enumerates more than one hundred works and papers of reference; and a third gives a useful classification of the animal kingdom, with brief distinguishing characters of larger groups and references to the pages of this work, in which orders and families are mentioned. An index and glossary conclude the four hundred and twelve pages.

The book is well described in the preface: "The general plan of this text-book is at the same time both old and new. Old, because it attempts to restore the old-time instruction in Natural History; new, because Natural History is not to-day what it was a generation ago. The treatment will seem new also in contrast with modern text-books of zoölogy, since they are devoted primarily to comparative anatomy, a field upon which we lay little stress. . . . It is a guide to the study of animals, which it is hoped may introduce many

[1] Davenport, C. B. and G. C. *Introduction to Zoölogy.* A Guide to the Study of Animals, for the use of Secondary Schools. New York, Macmillan, 1900. xii + 412 pp., 306 figs.

students to the sciences of comparative anatomy, comparative embryology, cytology, general physiology, variation and inheritance, and the others that are grouped under 'zoölogy.' This book is like a 'Synoptic Room' in the vestibule of a vast museum, containing the most essential things for those who can go in but a little way, but also fundamental for those who can penetrate farther."

This Natural History, vivified by general physiology, seems worthy to replace many of the school text-books now in use, if only the teacher be prepared to make the field and laboratory work dominate over the "cram" which presentation of so many facts makes an opening for.

The three hundred and eleven illustrations are a most important feature, remarkable in that the majority are from original photographs. Many of these are excellent, and, as the authors state, "their publication may be considered as something of a contribution to science." Yet it is to be regretted that, in some illustrations of invertebrates, black photographs have been preferred to good drawings; while, on the other hand, in the higher groups, notably the mammals, drawings of stuffed specimens have been used, where photographs from life, such as those of Gambier Bolton, might have been used to advantage.

We hope the book will meet with a success that will insure revisions. Meanwhile, the "blue crab" figured on page 109 will be of peculiar interest to the specialist.

E. A. A.

Merogeny. — The notable work of Yves Delage, first published in the *Comptes Rendus*, October, 1898, and in detail in the *Archives de Zoologie Experimentale*, VII, Nos. 3 and 4, 1899, widens the field of experimental research by a new method, and adds facts difficult to assimilate with the current conceptions of the phenomena of fertilization.

In the echinoderms *Strongylocentrotus lividus* and *Echinus sp.*, in the mollusk Dentalium, and in the annelid *Lanice conchylega*, he has succeeded in cutting eggs into two or more pieces and in keeping these pieces under observation in drops of water till they developed into the characteristic larvæ of these groups. In each case sperm was added, and it is inferred that it entered and fertilized the pieces. Moreover, in some echinoderm eggs the egg nucleus was seen in one piece and not in the other; yet the piece with no nucleus formed a larva just as well as did the piece with a nucleus. It is inferred that most of the fragments were without nuclei.

This development of fertilized, enucleated pieces of eggs the author calls merogenetic development.

In cleaving, such fragments tend to be abnormal at first, but by progressive self-regulation normal larvæ are formed.

In the sea-urchin three larvæ were got from one egg, and in another case an active blastula was obtained from a piece of egg one-thirty-seventh of the bulk of the normal egg.

In this well-controlled Gallic method of cutting a single egg while under observation under the microscope we seem much more sure of the results than in the former gross Teutonic method of shaking eggs wholesale in a tube, to break them to pieces. Still, the author finds it necessary to give reasons for rejecting the ideas, — that the egg was fertilized before cutting; that the cutting itself acted as a stimulus; and that the nucleus might have been cut to supply parts to each piece of egg.

In this he seems successful, except as to the last point, and we may still have doubts regarding the assumed restriction of the nucleus, or the nuclear matter, to one of the pieces. Another possibility, or indeed probability, the occurrence of polyspermy in these fragments, seems to have escaped the author's attention. This may vitiate some of his most important conclusions.

Incidentally the author points out that the cut halves of an egg may be drawn together again by the viscous envelope (we presume Hammar's layer) that is not necessarily severed. There is no evidence of "cytotropism" in this. On the other hand, there is often an abnormal tendency of the blastomeres to fall apart; we infer this is a state similar to that induced by Herbst in removing calcium.

It is interesting to find that the enucleated pieces may be bastardized by sperm of a related animal, but they do not develop when treated with the sperm of a widely different animal. In this the author sees the importance of the cytoplasm; and he also finds evidence of a maturation of the cytoplasm. Thus a ripe and an unripe egg in two drops on the same slide, when cut and treated with sperm, yielded for the ripe egg cleaving pieces in six out of ten cases, and none at all in the unripe eggs.

Granting that these merogenic larvæ are actually fertilized, enucleated pieces of an egg, it is a very remarkable fact that they have eighteen chromosomes in the nuclei of their cells, for this is the normal number that is commonly held to have come about by the addition of nine chromosomes in the sperm to nine in the nucleus of

the egg, yet in this case we start with only the nine of the sperm and have no egg nucleus at all in the fragment studied. Delage concludes that the constant number of chromosomes, *n*, is a constant factor of the cells, as are the contractile or secretive functions of cells, and that it is not produced by the activities of chromosomes acting as individuals.

In the last paper he defines his position as to the meaning and nature of fertilization. Assuming that experiment has shown that a piece of egg protoplasm, with no nucleus, can form an embryo if combined with a sperm, and not otherwise, he affirms that the essential thing in fertilization is this union of egg cytoplasm with the sperm. The egg nucleus is not necessary for the formation of a larva. Moreover, his experiments show that the per cent of fragments developing is larger than the per cent of whole eggs developing under given conditions, and he infers that the egg nucleus is not only unnecessary, but even a hindrance to fertilization.

In normal fertilization he regards the nuclear phenomena as rather a *substitution* of a male for a female nucleus than as a combination of the two. He does not deny that the egg nucleus is of use to the race in aiding in handing down characters of the maternal side, it may be; but to the making of the individual it is not useful, but detrimental.

Accepting the recent experiments upon echinoderm eggs, in which they are stimulated by chemical agents to develop parthenogenetically, he supposes that in fertilization the sperm nucleus is the active stimulating factor, while the egg nucleus is inert — to such an extent as to inhibit the sperm to some extent. Extending this idea, he supposes that the process of maturation of the egg is to be interpreted as follows. The polar bodies take from the egg nuclear matter and so reduce the inertness of the egg nucleus to a point where the sperm may overcome what is left. Were there no polar bodies, the sperm could not overcome the inertness of the entire egg nucleus.

E. A. A.

Skeleton of the Black Bass. — The skeleton of the black bass, on which Dr. Shufeldt has already made several interesting reports, has been described by him in full in a recent memoir.[1] This is accompanied by eight well-executed figures which illustrate in particular the structure of the skull of this fish. The text includes

[1] Shufeldt, R. W. The Skeleton of the Black Bass, *U. S. Fish Comm. Bulletin for 1899*, pp. 311–320. 1900.

some elementary directions as to methods of preparation and study, as well as a description of the parts under consideration, and is written from the standpoint of the older anatomy. Thus the statement is made that the black bass seems invariably to have thirty vertebræ, though in a former count the author reported thirty-two. His present changed opinion rests on the examination, as he tells us, of two perfect specimens, a rather limited number on which to base a general statement, and certainly not sufficient to show that the former count of thirty-two may not at times be realized. The modern anatomist is beginning to appreciate the fact that perfect uniformity in the number of parts is rather the exception than the rule, and that the truth of the matter is often better expressed in statements indicative of the range of variation in structures than in careful descriptions of them from one or two individuals. In this respect Dr. Shufeldt's work belongs to the older school. P.

Skeleton of Vulpes Macrotis. — The fact that the skeletons of none of our smaller western foxes have ever been fully described has led Dr. Shufeldt[1] to prepare an account of the osteology of *Vulpes macrotis.* The description is taken from a single specimen collected in Arizona and now in Dr. Shufeldt's possession. An exhaustive study has brought to light many points of resemblance and difference in the skeleton of this species as compared with those of closely allied forms, but without disclosing any important morphological matters. In the account of the skull, Dr. Shufeldt takes the late Dr. Elliott Coues to task for having systematically ignored the turbinal masses, and yet lays himself open to the same criticism by giving no description of these parts in the animal under consideration. To the scientific reader the text is somewhat marred by insertions such as those pertaining to the clavicles. These bones were missing in the specimen described by Dr. Shufeldt, and yet the reader is informed that "there is every reason to suppose that they agreed in their general character with the vulpine carnivora generally; that is, in some respects they were rudimentary and did not reach either the acromion or the sternum." Statements of this kind add nothing of importance to osteological descriptions such as this paper abounds in, and tend to discredit what is otherwise a commendable collection of anatomical details. P.

[1] Shufeldt, R. W. The Osteology of Vulpes Macrotis. *Journ. Acad. Nat. Sci. Philadelphia.* Vol. XI, pp. 393–418. Pls. XXII, XXIII. 1900.

Notes. — Professor M. M. Metcalf's extended studies on the tunicates have been published in the *Zoölogische Jahrbücher* as a series of short articles under the general heading "Notes on the Morphology of the Tunicata."

On the basis of recent studies on the life history of certain gregarines, Léger and Dubosca (*C. R. Acad. Sci. Paris*, 5 Juin, 1900) find that the epimerite alone is intracellular, and maintain that, contrary to generally accepted views, a true intracellular stage in development is very exceptional among these forms.

A detailed description of two fish tapeworms from the Great Lakes is given by Benedict (*Journ. Morph.*, Vol. XVI, pp. 337–368, 1 pl.). One is a well-known European form, and the other an imperfectly known species originally described by Leidy. Both belong to the genus Proteocephalus Weinland (= Ichthyotænia Lönnberg), which is shown to be more complicated in structure than hitherto supposed.

In his chapter on the entozoa, in the *Fauna Hawaiiensis* (Vol. II, Pt. IV, pp. 427–441, 2 pls.), Shipley reprints with emendations the description of the peculiar form *Apororhynchus* (= *Arhynchus*) *hemignathi* which he had previously discussed. It is important as the only known Acanthocephalon with no trace of the evertible proboscis and hooks ordinarily accepted as characteristic of the group.

A number of new genera of North American Hydrachnidæ are described and figured by Wolcott (*Trans. Amer. Micr. Soc.*, Vol. XXI, pp. 177–200, 4 pls.). The only one in the list which was previously known was reported once each from Russia and Venezuela, and is exceedingly aberrant in structure.

A new cestode of peculiar structure has been found in the turkey and is described by Ransom (*Trans. Amer. Micr. Soc.*, Vol. XXI, pp. 213–226, 2 pls.). It is characterized by the migration of the eggs in masses from the uterus to a point nearer the center of the proglottid, where a prominent egg capsule is secondarily constructed to include them. The uterus then becomes reduced, until it disappears entirely, — whence the name given to the form, *Metroliasthes lucida*.

The plankton of Echo River, Mammoth Cave, Kentucky, as listed by Kofoid (*Trans. Amer. Micr. Soc.*, Vol. XXI, pp. 113–126) from collections made by Eigenmann, is characterized by absence of plant life, particularly diatoms, by absence of rotifers, by predominance of

copepods, and by the presence of many littoral species. Among all the forms listed, twenty in all, few, if indeed any at all, are stygian, while most are common epigean forms. The author thinks that free access of surface water provides for the renewal of the plankton and prevents the development of peculiar cave forms.

The annelids of the Nordenskjöld expedition to Patagonia have been studied by Ehlers (*Nachr. Ges. Wiss.*, Göttingen, 1900, Heft 2). The collection embraced eighty-four species, of which twenty-one were new, and supplements well that made by Michaelsen in the same region. Three species and two varieties are noted as characteristically "bipolar" in distribution so far as known at present.

Jägerskiöld has given (*Centralb. Bakt.*, 1 Abt., Vol. XXIV, p. 737) a valuable discussion of the curious rosette organs of the lateral line in ascarids. Though exceedingly variable in different species, they are undoubtedly homologous; their function must still be left uncertain, though size and development show them to be active and important.

Van Denburgh and Wight (*Amer. Journ. of Phys.*, Vol. IV, p. 209) have studied the more important effects of the poison of the Gila Monster (*Heloderma suspectum*). A subcutaneous injection of six or seven drops into the groin of a dog was followed by death in less than twenty-four hours. Observations on numerous cases showed that the poison acted directly upon the respiratory center, causing a quickening and then a gradual paralysis of the respiratory mechanism. When artificial respiration was resorted to, death nevertheless supervened as a result of cardiac failure, showing that the heart is profoundly affected as well as the respiratory apparatus. The authors conclude that the effects of the Gila Monster poison are in no important respect different from those of the venom of various poisonous snakes.

H. M. Vernon (*Phil. Trans. Roy. Soc.*, 1898) brings additional evidence to that furnished by Seeliger and by Morgan to show that Boveri's (*American Naturalist*, March, 1893 and 1895) famous attempt to establish by experiment the dependence of adult characters upon chromosomes did not rest upon a firm basis. He finds that in the echinoderms bastards resemble now one parent, now the other, according to the time of year in which the crossing was carried on. He concludes that the "characteristics of the hybrid offspring depend directly upon the relative degrees of maturity of the sexual products."

The Oregon State Biologist, Professor F. L. Washburn, has just published a brief illustrated account of the food fishes of the Oregon coast. The pamphlet includes brief descriptions of some dozen food fishes, accompanied by photographic and other illustrations, and marks a beginning in the systematic study of the food fishes of the state.

BOTANY.

Mrs. Dana's Wild Flowers.[1] — Mrs. Dana's now well-known book owes its inspiration to an idea of Mr. Burroughs', that some day a book would appear by which our wild flowers should be made known without the trouble of analyzing them; and his suggestion of color and season as the leading means of attaining this seemingly desirable end has been faithfully worked out in it. Seven years have elapsed since the first edition appeared, and the fact that the edition now under review marks the issuance of the fifty-sixth thousand shows that it has met with measurable favor. Opinions have differed as to its real value. People who love but do not know flowers, and who want to learn their names without trouble, have always liked it. People who believe that one might as well learn botany while learning the names of the commoner and more showy plants have not infrequently regretted its publication. While the present reviewer would not start a student of botany with it, he believes it to be a very good book of its kind and for persons who will not go at the study in more than a holiday spirit, and it is a delight to thumb its pages. It may be that the numerous colored plates which form the novel feature of the new edition add to the value of the book, and they certainly are well done for three-color work, and will add to its salability.

T.

Our Native Trees.[2] — Miss Keeler has made a very commendable addition to the semi-popular treatises on American plants, in a

[1] Dana, Mrs. W. S. *How to Know the Wild Flowers.* A Guide to the Names, Haunts, and Habits of our Common Wild Flowers. Illustrated by Marian Satterlee and Elsie Louise Shaw. New edition, with colored plates. New York, Charles Scribner's Sons, 1900. 8vo, xxxix + 346 pp.

[2] Keeler, Harriet L. *On Native Trees and How to Identify Them.* A Popular Study of their Habits and their Peculiarities. New York, Charles Scribner's Sons, 1900. 8vo, xxiii + 533 pp., with 178 illustrations from photographs and 162 illustrations from drawings.

well-written, well-illustrated, and well-printed account of the native and naturalized trees of the "Manual" region. Bits of the best from poets and prose-writers relieve the monotony of description, and the folklore of a number of trees is well if briefly told. T.

Clements and Cutler's Manual.[1] — Dr. Bessey has long taken not only a theoretical but a very practical interest in secondary school training in the sciences, and the Nebraska high schools are reaching the point where their graduates can be said as a class to be better prepared for the real and serious study of botany for having had botany before entering college. Dr. Clements, of the University of Nebraska, and Mr. Cutler, of the Beatrice High School, have prepared this little book as an authoritative expression from the University upon the desirable kind and amount of such preparatory study. And while its use is likely to be limited to Nebraska, it may well find place in the working library of any high school. T.

Notes. — "The Plant Covering of Ocracoke Island," a study in the ecology of the North Carolina strand vegetation, by Thomas H. Kearney, Jr., constitutes No. 5 of the current volume of *Contributions from the United States National Herbarium.* It is illustrated by a number of figures in the text, representing structural adaptations.

A paper by R. M. Harper, on the flora of Sumter County, Georgia, appears in the *Bulletin of the Torrey Botanical Club* for August. Ecological lists, of some four hundred or five hundred species, are followed by critical notes on a considerable number of the species.

A systematic key to the phanerogamic spring flora of Kansas City and vicinity has been prepared by Kenneth K. Mackenzie, for use in the high schools of that city, and is published as an octavo pamphlet of twenty-three pages.

In the *Botanical Gazette* for September, Professor Nelson begins a series of "Contributions from the Rocky Mountain Herbarium," consisting of descriptions and critical notes on species and varieties believed to be undescribed.

Part IV of Professor Piper's "New and Noteworthy Northwestern Plants," in the July *Bulletin of the Torrey Botanical Club*, contains a considerable number of new species, of various dicotyledonous groups.

[1] Clements, F. E., and Cutler, I. S. A Laboratory Manual of High School Botany. Lincoln, Nebraska, The University Publishing Company, 1900. 8vo, 123 pp.

With fascicle 124, issued in April, Part III of Vol. XIII of the *Flora Brasiliensis* is brought to a conclusion, with title-page and index. The volume includes the natural families Polygalaceæ, Turneraceæ, Caricaceæ, Loasaceæ, and Sapindaceæ.

The third part of a series of papers on Mexican materia medica, by a number of students, has recently been issued by the *Instituto Médico Nacional*, of the City of Mexico.

In *Publication No. 50* of the Field Columbian Museum, Dr. Millspaugh publishes a reconsideration of the Cyperaceæ and of Cakile as treated in his earlier paper on the Antillean cruise of Mr. Armour's yacht *Utowana*, in the West Indian and Central American region.

A catalogue of plants collected by Don José Blain on the Isle of Pines, Cuba, is published by Dr. Millspaugh as *Publication No. 48* of the Field Columbian Museum.

The synonymy of several North American species of Eryngium is reviewed by Britten and Baker in a recent number of the *Journal of Botany*.

Part III of Mrs. Brandegee's "Notes on Cacteæ" is published in *Zoe* for July.

Von Seemen describes two Colorado willows, supposed to be new, in Heft 2 of Vol. XXIX of Engler's *Botanische Jahrbücher*.

Hydastylus, a genus proposed in 1812 by Dryander and Salisbury for the plant which has commonly been known as *Sisyrinchium Californicum*, is revived by Bicknell in the *Bulletin of the Torrey Botanical Club* for July, and is now made to include twelve species, all of Mexico or the Pacific United States.

Recent numbers of the *Acta Horti Petropolitani* are largely occupied by papers on Orchidaceæ, by Klinge.

Exoascus deformans, and the means of controlling the leaf-curl of the peach due to it, form the subject of an extensive bulletin by Newton B. Pierce, recently published by the United States Department of Agriculture.

Variation among pathogenic bacteria, a fruitful subject for study, is considered by Dr. Theobald Smith in a paper recently reprinted from the *Journal of the Boston Society of Medical Sciences*. From the seeming fact that new disease germs are not constantly

appearing, Dr. Smith argues that most species cannot adapt themselves to a parasitic existence, but that the many germ diseases are due to a comparatively small number of primary species, endowed from the beginning with certain fighting or invasive characters, and subsequently adapted to various hosts.

Mr. E. S. Salmon's recent monograph of the Erysiphaceæ, in the *Memoirs of the Torrey Botanical Club*, is followed in the August number of the *Bulletin* of the same society by a paper on the Japanese representatives of the same group, with a host-index.

The interesting smut genus *Mycosyrinx* forms the subject of a paper by Penzig in a recent number of *Malpighia*.

Notwithstanding his advanced age, Professor Oudemans continues his studies of fungi, and has recently distributed the first of a series of "Contributions to the Knowledge of Some Undescribed or Imperfectly Known Fungi" (in English) from the *Proceedings of the Royal Academy* of Amsterdam.

The needs of a young and growing botanical garden are modestly stated in the August number of the *Journal of the New York Botanical Garden*.

"A Study of Plant Adaptations" is the title of *Bulletin 69* of the Rhode Island Agricultural Experiment Station.

PUBLICATIONS RECEIVED.

(Regular exchanges are not included.)

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ASHMEAD, W. H. Classification of the Ichneumon Flies, or the Superfamily Ichneumonoidea. *Proc. U. S. Nat. Mus.* Vol. xxiii, pp. 1–220. — BUSK, A. New Species of Moths of the Superfamily Tineina from Florida. *Proc. U. S. Nat. Mus.* Vol. xxiii, pp. 225–254, Pl. I. — COVILLE, F. S. Papers from the Harriman Alaska Expedition. IV, The Tree Willows of Alaska. *Proc. Wash. Acad. Sci.* Vol. ii, pp. 275–286, Pl. XV. — CORBETT, L. C. Fruit Diseases and how to Treat them. *Bull. W. Va. Agr. Exp. Sta.*, No. 66. Pp. 199–235, 23 figs. — DYAR, H. G. Life Histories of Some North American Moths. *Proc. U. S. Nat. Mus.* Vol. xxiii. Pp. 255–284. — EVANS, A. Papers from the Harriman Alaska Expedition. V, Notes on the Hepaticæ Collected in Alaska. *Proc. Wash. Acad. Sci.* Vol. ii, pp. 287–314, Pls. XVI–XVIII. — GRAVES, H. S. The Practice of Forestry by Private Owners. *Year Book*, Department of Agriculture for 1899. Pp. 415–428, 4 pls. — HOPKINS, A. D. The Hessian Fly in West Virginia and how to Prevent Losses from its Ravages. *Bull. W. Va. Agr. Exp. Sta.*, No. 67. Pp. 239–250, 2 pls. and map. — INBY, B. Corn Culture in North Carolina. *Bull. North Car. Coll. Agr. and Mech. Arts*, No. 171. Pp. 27–43. — LUCAS, F. A. A New Rhinoceros, Trigonias Osborni, from the Miocene of South Dakota. *Proc. U. S. Nat. Mus.* Vol. xxiii, pp. 221–223, 2 figs. — NUTTING, C. C. American Hydroids. Part I, The Plumularidæ. *U. S. Nat. Mus., Special Bulletin*, 1900. 285 pp., 4to, 34 pls. — PINCHOT, G. Progress of Forestry in the United States. *Year Book*, Department of Agriculture for 1899. Pp. 293–306, 4 pls. — RITTER, W. E., and CROCKER, G. R. Papers from the Harriman Alaska Expedition. III, Multiplication of Rays and Bilateral Symmetry in the 20-Rayed Starfish, Pycnopodia Helianthoides (Stimpson). *Proc. Wash. Acad. Sci.* Vol. ii, pp. 247–274, Pls. XIII–XIV. — ROBERTSON, ALICE. Papers from the Harriman Alaska Expedition. VI, The Bryozoa. *Proc. Wash. Acad. Sci.* Vol. ii, pp. 315–340, Pls. XIX–XXI. — SHUFELDT, R. W. Professor Collett on the Morphology of the Cranium and the Auricular Openings in the North-European Species of the Family Strigidæ. *Journ. Morph.* Vol. xvii, No. 1, pp. 120–174, Pls. XV–XIX. — SIMPSON, C. T. Synopsis of the Naiades, or Pearly Fresh-Water Mussels. *Proc. U. S. Nat. Mus.* Vol. xxii, pp. 501–1044, Pl. XVIII. — SMITH, J. P. Contributions to Biology from the Hopkins Seaside Laboratory of the Leland Stanford Jr. University. XXII, The Development and Phylogeny of Placenticeras. From *Proc. Cal. Acad. Sci.* [3], Geol. Vol. i,

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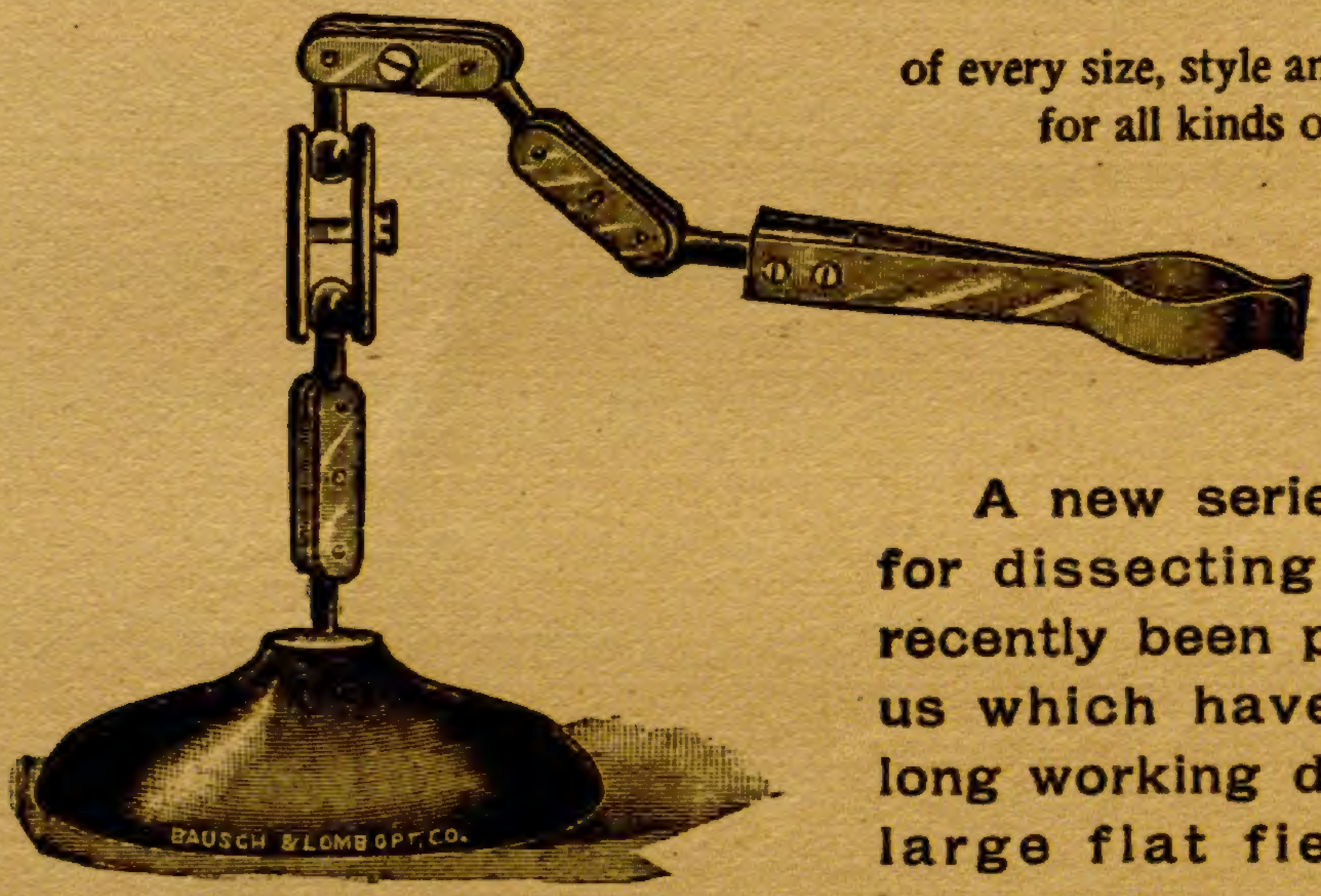

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